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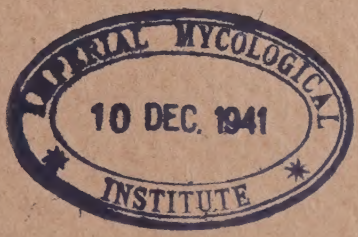

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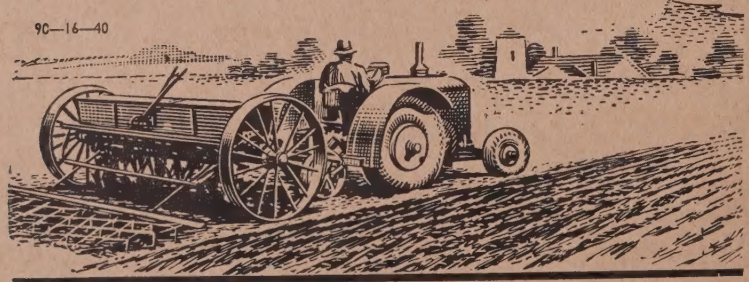

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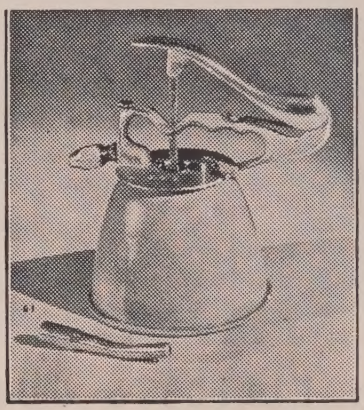

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The Productivity of Primary Industry

A CRITICAL ANALYSIS

By

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Graduates in agriculture have, during their studies, to do at least an elementary course in economics, but all economists are not given a course in agriculture. The result is that if an economist tackles an agricultural question, he is liable to arrive at conclusions in disagreement with the facts. Such appears to be the position of Mr. Colin Clark in the chapter, " The Productivity of Primary Industry " in his recent book, " The Conditions of Economic Progress ". This book, as its name implies, is an attempt to compare the economic condition of the people of the chief countries of the world, and the basis used has, generally speaking, been that of comparative productivity.

Although, as agricultural scientists, the members of the A.I.A.S. are generally interested in economic welfare, they are specially interested in the chapter above-mentioned. In outline the chapter comprises, firstly, estimates of the value of the total primary production in each country ; secondly, an estimate of the production per rural worker and a discussion regarding the figures submitted ; and thirdly, a general discussion on such matters as labour required to produce an adequate food supply, the effect of mechanization in agriculture, and the relation between farm size and capital invested and efficiency in production.

Although not altogether in agreement with the text of the chapter, the agriculturalist reads on, but comes to a full stop at a table, opposite page 244, concluding with the comparative productivity per rural worker in various countries, the striking ones being Australia 1524, New Zealand 2444, U.S.A. 661, Canada 618 and Great Britain 475. Working back through the table, he finds that the figures are in what are described as International Units, but which in this table are actually United States dollars, and that they represent average productivity in 1934 and 1935. For that period the Australian and New Zealand pounds were worth almost

exactly four dollars, so that in Australian currency the figures are: Australia £381, New Zealand £611, U.S.A. £165, Canada £154 and Great Britain £119.

Members of the A.I.A.S. have all met New Zealanders at various conferences; some have visited the Dominion, and many have read the book "Agricultural Organization in New Zealand". From none of these sources was the impression gained that the production of the New Zealand farmer and rural worker was nearly double that of the Australian. It is hard to see how this could be—New Zealand's main industries are the same as those of Australia (dairying and sheep raising)—although not in the same proportions, and the sheep and wool industry varies in detail. In the same way those who have had the opportunity of studying British and American agriculture would not be prepared to admit that the productivity per rural worker is respectively only one-third and one-half of that in Australia. We are aware that in each country certain areas have marked disabilities, but in spite of these, the proportion between the average rural worker in these countries and his compere in Australia and New Zealand seems wrong.

It is, therefore, necessary to go back to the preceding pages and follow out in detail the method by which these figures were obtained. This was as follows: the average production of each form of primary production for the years 1934 and 1935 was obtained and a value was given to this production by assessing it at the average price received by the United States of American farmer over the period 1925-1934. There were two exceptions—wool and silk. The former was valued at the average Australian price and the latter at the average Japanese price. The values used are given in U.S. dollars per quintal (220·4 lb.) and, in the following table, are given the values allotted to some of the leading products, their Australian equivalent, and what average Australian and New Zealand prices are available for the period 1925-34.

Product.	Value Used per Quintal.	Australian Equivalent, 4 Dollars to £1.	Australian and New Zealand Prices.
	Dollars.	Pence.	
Dairy products (as milk).	3·95	10·07 per gal. 25·17 per lb. butter fat	Victorian average, 15·8d. per lb. butter fat.† N.Z. average, 13·8d. per lb. butter fat.*
Sheep and lambs (dressed weight).	27·1	7·39 per lb.	†Victorian prices, lambs 6·3d. per lb. sheep 4·22d. ,, ,, *N. Zealand ,, lambs 7·0d. ,, ,, sheep 4·0d. ,, ,,
Wool (greasy) ..	56·6	15·41 per lb.	†Australian average, 15·48d. per lb. ‡N. Zealand ,, 11·21d. ,, ,,
Wheat	3·27	53·41 per bush.	§Australian price, 47·8d. per bush.
Cattle and calves (dressed weight).	20·0	5·45 per lb.	†Victorian price, 4·34d. per lb. *New Zealand, approximately that of Victoria; if anything, lower.

* From export values in New Zealand Yearbooks.
† From Victorian Government Statist.
‡ From Dalgety's Wool Review, 1939–40.
§ From Commonwealth Statistician.

It is readily seen that there are considerable differences between the values used by Mr. Clark and the Australian and New Zealand prices. The results, therefore,

cannot be used as an indication of the prosperity of the Australian and New Zealand rural producers. Their prosperity depends primarily on what they receive, not on what the American farmer would have received if he had produced the same quality produce in the same quantities. These prices are also the key to the difference between the Australian and New Zealand figures. Milk products form the greater part of New Zealand's produce, and, therefore, the crediting of these at inflated prices affects the total New Zealand return in greater proportion than the Australian. The New Zealand return is also higher because their wool has been valued at the Australian price, which, on account of the quality, was for the period 1925-34, 3·47 pence higher than that of the Dominion. It is realised, on the other hand, that New Zealand lambs are of better average quality than the Australian, but the difference during the period was approximately 10 per cent. as compared with 25 per cent. in wool values.

Another item that would favour New Zealand is that no allowance seems to have been made for skim-milk and whey fed to poultry, pigs and calves. There is considerable discussion regarding the precautions necessary to prevent double calculation of cereals and cereal products fed to animals (a mistake made by another economist), but allowance for the skim-milk and whey has been omitted. This is another error due to lack of knowledge of the subject.

The main reasons for these figures being out of proportion to the actual returns are, therefore :

(*a*) Adoption of a uniform price.
(*b*) No allowance for difference in quality.

Uniform Prices.

The differences in quality cause considerable differences in return, but Mr. Clark might be excused for missing these on account of his ignorance of agriculture, but it is difficult to follow his arguments as to why uniform prices should be adopted. They are :

(1) " It obviates false valuations due to maintenance of internal prices above the world level.
(2) " The measurements of productivity of primary produce in different countries can be compared with our measures of real income.
(3) " She (U.S.A.) produces virtually every type of agricultural and pastoral product competitively with the world market.
(4) " She has excellent records of the average prices received by farmers."

Commencing with (1), this may be so in the case of products exported from U.S.A., but it does not apply in those cases where the perishable nature of the product makes it a local one or where the U.S.A. does not export and has a duty on imports. Of the various products listed in the table opposite page 244, market milk, cream and potatoes come under the first category, and meat and butter—on which there are duties of 6 and 14 cents, respectively—in the second.

In respect to (2) the validity of this argument depends on whether it is correct to compare productivity by determining values of production on a uniform basis. There are so many agricultural products which are perishable and, therefore, must be produced in the country of consumption, that it does not appear reasonable to value all production on a uniform basis ; as an example, the production of fresh milk in Norway is expensive, imported food has to be used, and on account of climatic conditions the number of cows that can be handled by one worker is probably half what it is in Australia. Is it sound economics to compare the productivity of the Norwegian dairyman with that of the Australian on the same price basis ? Although this is an extreme case, the same condition applies to a less extent in other countries and industries. It seems, therefore, that the comparative efficiency of the rural

workers in each country can be compared more closely if local prices are used. Actually " real income " depends on the consumption goods received for the goods produced, and therefore real incomes can only be compared by a comparison of consumption goods available. As the prices of consumption goods in dollars vary from country to country, it is difficult to see how a comparison of productivity on one set of prices can give a comparison of real income.

Reason (3) states that U.S.A. produces virtually every type of agricultural and pastoral product (excepting wool and silk) competitively with the world market. While this statement may have been true thirty years ago, it is not so at present. Of the 27 products listed on the table opposite page 244, it is doubtful if there are more than seven for which the price received by the U.S. farmer is fixed in world prices, and whether out of the total primary production of U.S.A. of 6,550 million dollars the price of more than one-third is fixed in world prices. In U.S.A., as in Australia, practically every primary product is protected by a duty and in a number of cases where there is a small export proportion it has little effect on the price throughout the length and breadth of the country.

With respect to reason (4), " she (U.S.A.) had excellent records of the average prices received by farmers ", this is not a sound argument if the figures are generally speaking inapplicable. Take, for instance, milk products. In U.S.A. the proportion of milk used fresh, e.g. either as fresh milk, cream or ice-cream, is approximately 40 per cent. ; in Australia, for the years in question, it was approximately 3 per cent., and in New Zealand even lower.

The price of whole milk is, therefore, a very definite factor in fixing the U.S.A. farmers' price. This destroys its utility as a world price, as the price of whole milk, particularly supplies to large cities, is fixed by local costs of production, not by world competition. The U.S. farmers' price for milk is, therefore, likely to be a price higher than the world's competitive price for all milk, including that used for milk products.

Turning to the meat classifications, the prices of dressed cattle, pigs, sheep and lambs will also be influenced to some extent by local conditions. This is particularly so in the case of sheep and lambs in U.S.A., the price depending on the supply to the U.S. market. There is, as stated above, a heavy duty on all classes of meat into the U.S.A.

The poultry price of 50 dollars per quintal seems high to the Australian, and this is due to its being an average " turkey " price, rather than a " domestic fowl " one, which it would be in Australia. Actually the retail price of poultry in Melbourne is below this figure, on the basis of 4 dollars to the £1.

Eggs are another line, the U.S. price of which to the farmer would not be fixed by world competition. The main market eggs are produced in California and the main markets are in the eastern States, so that the price to the producer will depend on his location, as packing and transport charges are high in proportion to the value.

Turning to the remainder of the chapter, other subjects dealt with are, as mentioned previously, the relation of area and capital to return per rural worker, effects of mechanization, and relative values of tractors and horses in agriculture. In the discussion of these subjects, tables and conclusions from various sources are quoted. The relationship between area and efficiency of production is an intriguing one, and on it Mr. Clark has quoted a number of investigations made in various countries, none of them, however, Australian. The agricultural scientist, however, who has investigated the subject, finds that other factors are so important that it is impossible to show any correlation except in respect of one industry under one set of conditions.

In Victoria, as many readers will remember, an attempt was made in 1930-31 by the Land Settlement Authority to decide on " Living Areas " for various forms

of agriculture. Although "living areas" may not be identical with "optimum areas", they should be closely correlated with them, and the variations in the decisions are, therefore, of interest—these ranged from 17 acres in the case of vine-growers to 1,280 acres in the case of wheatgrowers in the north-west of the State. For wheatgrowers only the variation was from the 1,280 acres to 480 acres in a more favoured portion of the State. In view of these variations, what use is an average?

While dealing with this subject, it is difficult to understand a table on page 272 (taken from a New Zealand report on the cost of producing butter fat) which sets out butterfat produced per man-year of labour, and the acreage used for dairying with varying sized herds. The trend of the table is shown by the following extracts:

Size of Milking Herds. (Number of Cows.)	Butterfat Produced per Manpower Year of Labour.	Acreage Used for Dairying.
10–20	2,190	27·2
30–40	4,028	41·9
50–60	5,130	48·7
70–80	6,051	51·8
180–220	7,097	53·5
Over 300	7,576	52·0

The more this table is examined, the more extraordinary it seems. It is common knowledge among agriculturalists that land which will carry more than one cow to the acre, that is provide it with all roughage required, is very scarce, and this is confirmed for New Zealand in the book, "Agricultural Organization in New Zealand", where it is shown by a table that only one-half per cent. of farms carry one cow or more to the acre. It therefore appears that as the herds included in the above table increased over, say 40 cows, they were fed more and more purchased feed, until the herd of over 300 would be fed almost entirely on purchased feed. To use such a table in an endeavour to prove an optimum farm area seems, to the agriculturalist, ridiculous.

Readers should not think from the above criticism that Mr. Clark's book is not worth reading. It most certainly is, as it gives a comprehensive analysis of economic progress, both in time and space. Although one may not agree with it in its entirety, it makes one think. What I have desired to show, however, is the failure of economists generally to realise that the economics of agriculture need special study, and that a training in economics and statistics as applied to industrial and financial organization does not make one competent to write on agricultural economics. One well-known economist was recently reported to have stated that he was competent to deal with the problems of farmers, because, *inter alia*, he was brought up on a farm. What would be his reaction to the agriculturalist who said he was competent to deal with the problems of business men because he had worked in his father's corner store? On the other hand, members of our Institute tend to interest themselves almost entirely in the scientific side of agriculture. The importance of the economic side of agriculture should also be realised. Members of the Institute should, therefore, study and interest themselves in this aspect of their profession, so that they will be able and competent to display such knowledge of agricultural economics that they, and not economists trained in the business world, will be considered the authorities on this subject.

(Received for publication, 22nd May, 1941.)

Land Use

By

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In its broadest sense, efficient land use may be defined as the best pattern of uses which can be adopted on any area in order to give the maximum permanent prosperity to its inhabitants. It includes almost the whole of man's activities. A stretch of land may be used for various forms of agriculture, for forestry, residential purposes, factories, playing fields, aerodromes, public parks and so forth. It is obvious that on any area under a given set of economic conditions, there must be an ideal pattern of land use. Our own land use has been built up very largely and necessarily by the dictates of immediate circumstances—by economic, geographic and political pressure of the moment, sometimes influenced by tradition. It would be too much to hope in the absence of any predetermined knowledge of the environment or any preconceived plan, that our land use be ideal. We must attempt to plan our land use in future guided by a policy of restoration, maintenance or building of resources.

Non-Agricultural Requirements.

In Australia our areas are so vast in relation to population that we are inclined to discount the significance of the use of land for such non-agricultural purposes as urban building, factories, aerodromes or parks. Nevertheless it is of interest to examine the position in England and Wales. In the thirty years ended 1931, almost 700,000 acres were added to urban areas. Grandchildren of the present generation will witness the complete urbanisation of the county of Surrey. Other activities are slicing areas from the agricultural acreage ; roads and railroads occupy a million acres ; aerodromes will require at least 100,000 acres and playing fields 300,000 acres. Over 12 per cent. of England and Wales has already been used for non-agricultural purposes, an area equal to half the arable acreage. These non-agricultural activities have a valid claim for land surface, but unfortunately each of them is by preference developed on level land and hence usually on good agricultural land. The fertile Middlesex Market Gardening Plain to the west of London is already half consumed by housing and industry. Stapledon stresses that in the long run (and here he refers to periods of 100 to 500 years) it pays to build reservoirs, suburbs and aerodromes on land of little or no agricultural value—even though the initial cost be tenfold.

This problem is not acute in Australia, but planning is nevertheless worth while. If a township can spread in one direction on land of little agricultural value, there is no reason why spread should occur in another direction on to highly productive land. We have an enormous land surface, but the area of high fertility land in favourable climatic regions and especially close to large centres of population is certainly not so great that we can afford to squander it.

Agricultural Land Use.

There is scarcely necessity to stress the desirability of efficient use of agricultural, pastoral and forest lands. These industries are supported by a few inches or a few feet of soil, and the first principle of agricultural or pastoral land use is the conservation of the soil, and the maintenance or building of its fertility. Extreme examples of land use are familiar from the older countries. In England we see an agriculture which has withstood the test of the centuries. The utilisation has not been and is

not ideal, but there has been no destruction of the ultimate resources. In contrast, in the countries of North Africa and the near East, the ruins of great and beautiful cities lie in country which now supports only nomadic Arabs. In Mesopotamia, a valley which previously supported a cultured civilisation of forty million people now maintains only five million people at an appallingly low standard of living. These are notable examples of land destroyed by an agriculture not in equilibrium with the soil and climate.

In the younger countries there are equally gross, though less advanced, examples of misuse. At first the younger countries of the world have tended to adopt their agriculture from the countries of the Old World. With appreciation of the difference of environment, agriculture has become progressively modified, but unfortunately the modification has frequently been towards an exploitive rather than a stable agriculture.

Semi-Arid Regions.

This is especially the case in semi-arid regions where the equilibrium between climate, soil, vegetation and grazing animals is easily and sometimes permanently destroyed. In any country which has a proportion of semi-arid land it is necessary to recognise a boundary beyond which, because of erratic or deficient rainfall, no cultivation is possible and where dependence for grazing must be placed on the native vegetation. This boundary is not easily defined in newly settled countries and has invariably been overstepped, resulting in damage perhaps irreparable within a century.

Firstly, Australia. Here we have the example of the destruction of much of the saltbush shrub steppe by over-grazing. Before settlement occurred there was an equilibrium between the climate, the saltbush and a nomadic marsupial fauna. Droughts were a normal phase of climate and merely swung the equilibrium without destroying it. With the advent of man's domestic stock a new biotic environment was created. The grazing pressure was increased far above that previously existent, the stock was confined within fences and the numbers were not immediately reduced with the onset of drought. Radcliffe estimates that in the arid pastoral areas of South Australia the bush has been destroyed by grazing and trampling to the extent of 75-90 per cent. Rabbits and drought have merely increased and not created the rate of destruction.

In the western range of the United States overgrazing has been made even more severe by the land policy adopted. The public domain was free for all—first come first served. Big outfits established themselves with no other claim to the land than priority of arrival. Up to the end of the last century, and even later, successive feuds were waged between the big and small operator, cattle and sheep men. Feeling frequently ran high. A newcomer would be driven out by his powerful neighbour through the simple expedient of grazing bare all the public domain about him. The creed that profits depended on stock numbers dominated the graziers' outlook.

It is now estimated that the western range area has a carrying capacity only 48 per cent. of that in its virgin state, 10·8 million instead of 22·5 million animal units. The Americans are at least prepared to face the facts and admit that overgrazing is the cause of the depletion. Droughts, rodents, ill-advised land policy and financial difficulties have only tended to accentuate the evil of overgrazing. Here then are two of the many examples of the extreme reduction of the value of low rainfall pastoral country by overstocking.

Cultivation of these semi-arid grazing lands leads to even more disastrous results. A much publicised example is the notorious Dustbowl of the Southern Great Plains of America. Much of the agricultural settlement in this region occurred since the last war. Good grazing land was turned wrongside up and, for a season or

two, fair wheat crops and high prices were secured. Then came drought and drift. The soil lost its resistance to wind movement as the roots of the sod decomposed. Crops failed, fences were buried, great clouds of dust swept across America and out into the Atlantic, 1,500 miles distant. Thousands of acres of abandoned farm lands now carry nothing but the annual Russian thistle (*Salsola pestifer*), worthless to man or beast. It has been estimated that a minimum of 50 years would be necessary to permit natural re-vegetation with species of grazing value. Meanwhile the Federal Government is spending enormous sums in attempting to re-vegetate artificially.

In South Australia, during the twenty-year period ending 1935, no less than 23·5 per cent. of the wheat area produced an average yield of less than 6 bushels per acre ! It is the same tale of land suited only to grazing being misused for arable production—the same tale of wind erosion, abandonment of farms and human misery.

A zone must then be recognised in which carefully regulated grazing is the only efficient means of utilisation. Cultivation is disastrous, overgrazing will destroy the vegetation. The rate of stocking must be adjusted to the low annual production of forage and the violent seasonal fluctuations.

Cropping Districts.

In the better rainfall areas there is a pattern of crops and pastures each gaining local dominance.

Consider first the cropping districts, and here the wheat belt of Australia provides an excellent example. Much of our wheat farming has been based on the rotation, wheat-fallow or wheat-oats-fallow, helped along by superphosphate. We know that under these conditions a depletion of resources has occurred, in this case the surface soil. In the more serious cases, sheet erosion and gully erosion have virtually destroyed the soil. But frequently the deterioration is less obvious. Downes and Leeper have secured interesting results on the physical structure of long cultivated Victorian soils. They determined the percentage of the soil in water stable aggregates exceeding $\frac{1}{4}$ mm. in diameter, and expressed the remainder as the percentage disaggregation. On a virgin pasture at Merrigum, the percentage disaggregation was 32 per cent., on a much cultivated orchard 96 per cent. Native grassland at Werribee showed soil disaggregation of 26 per cent., 30 years' cultivated land 91 per cent. This loss of crumb structure with cultivation was paralleled by falling organic matter and increased apparent specific gravity.

Forster secured direct data on fertility trends under various cereal rotations in Victoria. At three centres a significant downward trend in the yield of oats in cereal-fallow rotations has occurred at the rate of $\frac{2}{3}$ bushel per annum for 18 years. Wheat yields in cereal-fallow rotations have remained constant, despite improved varieties and cultivation methods. Yet where grazed pasture has been included as a single season of the rotation, the wheat yields have shown upward trends. The evidence points to maintenance of organic matter and physical structure as the value of the grazed pasture. An American prairie soil showed a decline of 12 per cent. in pore space and 40 per cent. in water penetrability as a result of six years' continuous cropping to corn.

Loss by erosion is reduced by pastures because of greater water penetrability of the soil, the resistance of stable soil aggregates to wind or water movement, the breaking of the impact of the raindrops and the mechanical binding by the roots.

The following results were secured by Muller in Missouri on a 3·68 per cent. slope :

Cultural Treatment.	Percentage Runoff.	Average Annual Erosion in Tons of Soil per Acre.
Bare cultivated	.. 30	41·0
Continuous corn	.. 29	19·7
Rotation, wheat, clover	.. 14	2·7
Continuous bluegrass	.. 12	0·3

It is becoming increasingly clear that if fertility is to be maintained under Australian cropping conditions, then grazed pasture must be included in the rotation. In all parts of the wheat belt there is evidence of loss of soil structure, depletion of organic matter, wind and water erosion. An example of a desirable type of rotation is that recommended for the central section of the N.S.W. wheat belt. It alternates six years of cropping with six years of pasture. Even during the arable phase, one oat crop is devoted wholly and another partially, to grazing.

The trend towards mixed farming and away from single cropping is perhaps the most fundamental change in our agricultural outlook since pioneering days. It means that, instead of the prospect of a continually declining agriculture in our arable areas, we now can hope for a stable and fully permanent form of land use.

Pasture Regions.

In areas where pastures form the basis of land use we can recognise several zones.

There are pastures of native grasses where correct management is the only method of improvement. There are areas of native or naturalised grasses where superphosphate enables the development of legumes in the sward and a building of fertility. This fertility building through superphosphate, legume development and the return of animal droppings represents an excellent form of land use over enormous areas of South Australia. It has built poor soils low in organic matter to relatively high producing soils capable of carrying superior pasture plants. Finally, among our grasslands, we have areas in which sown or naturally established perennials form the basis of the sward. Although these are our most highly productive pastures, it is doubtful whether in such areas we have developed the most efficient land use. We know that as pastures age they tend to become sod-bound and unthrifty. Paspalum or Phalaris do so more rapidly than say, perennial ryegrass. But, undoubtedly, the tendency is for a decline in productivity of these sown pastures, fast or slow, depending on the pasture mixture and the management. Under these circumstances, the logical step is to adopt precisely the same practice as is recommended on the permanent grasslands of England—namely to plough, crop and then return to pasture. The pasture will be more productive than the old sward, worm infestation will be reduced and pasture weeds are destroyed by cultivation. At the same time the crop provides the farmer with a means of cash return for the accumulated fertility beneath an old well-grazed sward. It seems certain that a wider application of alternate farming could be adopted on much of our better rainfall areas, now designed to carry permanent sown pastures.

Survey.

How may we remedy past errors and how can we attempt to attain efficient land utilisation ?

The first step is to gather information, since it is impossible even to attempt intelligent planning unless adequate information is available. If the land surface is to be classified then it must first be surveyed. Stamp has listed six ways in which such a survey might be conducted. Soil surveys are extremely valuable but require considerable trained personnel and are very costly over extensive areas ; agricultural productivity suffers the disability of variation in farm practice ; land values involve

many complicating factors ; ecological surveys, such as pasture surveys, are very useful, especially where the native flora is still recognisable ; analysis of statistical returns is of value for distinction between major regions but does not differentiate smaller units ; and, finally, existing land use shows present and, in some instances, potential extent of various land industries. No one of these is perfect and the ideal survey would combine all of them in some degree.

Many surveys of one type or another have already been conducted in various countries. The grasslands of Wales, and more recently of England, have been surveyed. The survey of Wales showed that only 0·4 per cent. of the total area could be classed as ryegrass pastures, but that over 40 per cent. could be brought into this group by proper practices. On the basis of the Land Utilisation Survey of Britain, Stamp considers that its land use could be completely reconditioned. Arable areas could be increased from 22 to 31 per cent., economic forest and woodlands from 2·5 to 11·5 per cent. and so forth, by change of one form of land use to another, with final reduction of the area of heath, moorland and rough grazing. The United States Forestry Service is surveying the national forests from the viewpoint of present and ultimate stock carrying capacity. Numerous local bodies are making surveys of resources.

In Australia, we have as yet scarcely touched the problem of land survey. Recognition of the need for such surveys is developing on all sides, but it is still too often regarded as a sideline to be conducted by workers engaged primarily in other duties. Actually, it is a well defined field of endeavour and should be treated as such. A combination of an ecological and land use survey, accompanied by a varying intensity of soil survey according to the character of local problems, would probably give the greatest return for effort expended. It would show the *status quo*, and the distribution of industries in relation to climate, topography, the principal vegetation and soil types. Overgrazed, eroded or abandoned areas would be defined. Obviously, no method of survey can be applied to widely different environments without modification. Any survey must recognise local problems and, in order to guide local planning, must be adapted to the regional conditions. In many instances, however, broad aspects of policy of land use can be formulated without detailed survey. The discouragement of wheat growing in areas unsuited to continuous cereal production would not necessitate the inspection of every property in the affected region.

Research.

As a result of surveys, land use problems become more sharply crystallised, and research into specific problems is possible. The investigations in progress in New South Wales on suitable rotations for the wheat belt provide an excellent example of the type of work required. Other obvious land use problems are the management of low rainfall pastoral lands, study of the fertility building by subterranean clover, studies on the possible harmful effects of lucerne in permanently lowering the water table of drier areas, the influence of continued clean-cultivation in orchards, and so forth. But direct research on land use problems is only one phase of the research programme. A better coordination of all research is needed. At present the common meeting ground of two specialist research workers on different subjects is the crop. The entomologist and the horticulturist meet at the peach tree, the agronomist and pathologist at the wheat crop. There is no wide and common basis on which all research should be built. The plant breeder should not spend time breeding wheat varieties for areas in which wheat should never be grown, nor the pathologist in controlling some disease arising from unsound land use. If all work springs from the common basis of efficient land use, then coordination of effort must surely follow.

Research needs to be extended in scope beyond technical problems of production. We know too little of such subjects as climatology, land legislation, farm finance, farm tenure and the size of holding. All these require research.

Planning.

The next step is to plan land use on the basis of the results of survey and research. The land surface is classified according to the suitability of the environment to various forms of production and according to the level of production possible. Such classification must be elastic within wide limits. Professor Wadham has stressed the considerable dependence of land utilisation in Australia on the overseas demand for our products—on economic factors largely beyond our control. Obviously we cannot plan land use entirely on a basis of the most suitable activity in terms of soil, topography, vegetation or climate. The total area best suited to a particular crop may give a harvest far in excess of local and export requirements, while many essential crops would not be grown at all. But alternatives within the fluctuating economic framework are possible. There is no reason why rotations which result in serious soil erosion should be followed in any district when alternative and equally profitable rotations which conserve the soil are available. Instead of permitting higgledy-piggledy land use according to immediate economic circumstances, there must be some sort of plan. No such plan is likely to prove fully operative, but at least it provides a standard by which to guide development. Gross errors of the past should surely be avoidable in the future.

One of the most powerful weapons in the implementation of any plan is education. By constantly stressing the danger of a certain practice in a particular district and by offering alternative and sounder practices, at least a percentage of instances of wrong land use may be avoided. But education should have as an equally important objective the development of land-use consciousness in the whole community. If an undesirable practice leading, say, to serious soil erosion, incurred the extreme disapproval of the community, its use would tend to discontinue.

Demonstration is a natural corollary to education. This duty is carried by such bodies as the Soil Conservation Services and the Departments of Agriculture. Direct physical methods of prevention of erosion such as contour ridging or protection of waterways, and the relative ability of particular crops or rotations to conserve the soil and its fertility can be demonstrated. Usually, of course, such demonstration will be concurrent with research projects.

Local Organisations.

A land use plan must be nationally conceived because of the dependence on local and overseas markets, on defence measures, political relationships and so forth. But the details of planning, which are the final deciding force, must be of local origin and local administration. Intimate knowledge of an area is indispensable and much of the knowledge necessary to sane planning can be secured only by cooperation with the farming community. In organising any scheme for improved land use it is necessary to constitute local bodies in each natural land use region and to ensure ample producer-representation.

There are two such types of organisations in the United States. The first is the land use planning committee, set up in each county and State. These committees study local problems of land use and tender advice to the Federal authorities. In the aggregate, the advice so received shapes Federal policy on land use (within the framework of the legislation) and particularly the local aspects of Federal policy.

The second and even more striking local organisation is the Soil Conservation District. These are constituted by holding a ballot among land occupiers in any district, followed by the appointment of a governing body of five supervisors. This

body has power of two main types : (1) to establish and administer erosion control projects and preventive measures. (2) To prescribe land use regulations in the interests of the prevention and control of erosion. The S.C. district is a governmental subdivision of the State, designed to regulate land use within its boundaries, particularly in relation to existing and potential soil erosion. It is an expression of the concept of land use as a cooperative endeavour between neighbouring individuals. In such a district visited in eastern Nebraska, strip cropping, contour cultivation, field terraces, pasture ridges and furrows and controlled outlet channels were becoming accepted as normal farm practice. Admittedly much of the considerable work involved in constructing field terraces and so forth is made possible only with civilian conservation corps labour and with S.C.S. supervision.

Public Administration of Marginal Lands.

A far-reaching national concept which has become fully developed in America is that certain lands are unsuited to private ownership, or to unrestricted private operation. The suitability of land for private ownership and operation is directly dependent on the general favourability of the environment to the industry. Severe or unreliable climatic conditions, meagre and erratic forage production, heavy investments in land and improvements relative to mean production, high costs of supplemental feeds, long distances from markets and agistment areas and high general freight costs all militate against successful private ownership. Under such conditions the private operator is almost certain to adopt exploitive methods. Recognising this principle, the repurchase and subsequent operation by the State of alienated lands unsuited to private ownership are essential.

The United States has taken steps in this direction. In 1901 Theodore Roosevelt withdrew 194·5 million acres from the misused public domain as national forests and on these forests all activities are controlled. Multiple use is a recognised principle and lumbering, grazing, watershed protection, wild life preservation and recreation may each be developed as a function. No person can graze stock on a national forest unless he has a permit stating the number and kind of stock to be grazed, the date of entry and the period for which they may remain. After 30 years of management, the national forests are estimated to be restored to a carrying capacity of 70 per cent. of that in the virgin condition, as compared to 33 per cent. on the remainder of the public domain and 49 per cent. on privately owned range. The policy of securing public stewardship of low production lands was extended in 1934 by the withdrawal from alienation of all remaining public domain in the western States and the constitution of 61 million acres into Taylor grazing districts. In these districts public control of livestock numbers and season of grazing is becoming operative.

It is recognised that only the State has the financial strength to rehabilitate regions in which the natural resources of soil or vegetation have been largely destroyed. It is estimated that in the western United States there are some 15 million acres of abandoned farmlands, 113 million acres of submarginal range lands and 118 million acres of watersheds which should be returned to public ownership and administration. Tax delinquency is one means of reacquisition of private lands, but it permits depletion to continue to its lowest ebb and outright purchase seems the only feasible method. Already considerable areas have been acquired. For example, of the 700,000 acres in the tri-State project for revegetating abandoned farmlands on the Dustbowl, 148,000 acres have been acquired by the Federal Government by purchase. In Central Montana the reacquisition of 400,000 acres of land by purchase has enabled the Government to bring 4,000,000 acres under constructive range management by cooperation with local graziers.

Any country with vast low rainfall areas must consider the problem of the exploitation of marginal lands. In Australia we have been able to witness the destruction of resources by private operation of both marginal sheep-raising country and marginal wheat-growing lands.

Social Problems.

Where the form of land use adopted over a region is a failure, widespread human misery will result. Steinbeck's *Grapes of Wrath* is an account, admittedly overstated, of the poverty and despair of the wheatgrowers of the Dustbowl; similar, if less widespread, waste of human effort has occurred in our own dry districts. The rehabilitation of the land is one problem; the rehabilitation of the community is a separate and altogether more difficult one. Natural migration from marginal areas is constantly occurring, but each migrant is likely to leave only when resources are destroyed and his attitude has become one of defeatism. A more active policy than one of awaiting the breaking point must be adopted.

The Farm Security Administration, a New Deal organisation, is attempting to assist needy marginal farmers by advancing loans to enable them to adopt a system of farm management more in accordance with their environment. In many cases, however, the investment of capital is unwarranted on a land use basis, and in such cases a loan may be made to enable the purchase of a farm in a more favourable environment, the farm to be managed under a sound and approved plan. Such loans are, however, limited in number and subsistence relief is still all that can be offered to many marginal producers. Unfortunately it is true that the most glaring instances of wrong land use are the most difficult to solve because of the social disorganisation involved.

Financial Inducement.

Financial encouragement is a potent weapon in developing good land use. Loans to farmers by banks or other organisations are based on the ability of the individual to repay—that is by his immediate success in terms of £ s. d. Is it too much to hope that such loans might be granted on the basis of good or bad land use? If the long view is taken, no man who is destroying resources is deserving of financial aid or is even a good long-term risk, irrespective of his immediate ability to earn income, unless the loan is to enable him to change his practices.

Direct government subsidy of desirable farm practices is another method available. Such an approach is well exemplified by the activities of the Agricultural Adjustment Administration—the Triple A—of the United States. It postulates the principle that " economic pressure on the farmer is generally recognised as the major cause of unwise farm use ". He is driven to exploitive practices and it is the responsibility of the State to prevent this and to enable him to adopt wiser practices. Certain crops such as cotton, corn, wheat, rice, peanuts and potatoes are listed as soil-depleting crops. For each State, county and farm a maximum acreage allotment is given. (These allotments are subject to annual fluctuation under the " Ever-Normal Granary Program "). There is no compulsion, but the farmer receives a subsidy if he keeps within his acreage allotment. Further bonuses may be earned for the adoption of soil-building practices which fall into four groups: (1) seeding of soil conserving crops such as grasses and trees. (2) Application of fertilisers, mulching orchards, green manuring, etc. (3) Terracing. (4) A variety of erosion control measures, such as contour furrowing, strip cropping, reduction of stocking rate on range land, etc.

In 1937 the range-conservation programme involved subsidies in respect of 12,184,000 acres for deferred grazing; 2,365,000 acres for reduced rate of stocking; 80,000 acres for artificial reseeding; 60,000 acres for contour furrowing and listing;

1,677,000 acres for elimination of destructive plants ; 13,094,000 feet for construction of firebreaks and in respect of 27,553 earthen tanks.

It is inevitable that some abuses should occur, but the beneficial trend resulting from this subsidisation cannot be denied. In Australia we have done little in this direction. A bonus, in the form of a rebate on purchase price, was given to stimulate the application of superphosphate to pastures. But, by and large, immediate economic factors are still the principal guide to land use.

Summary.

The steps in securing efficient land use can be summarised as follows :

(1) Survey.
(2) Research.
(3) Planning.
(4) Realisation of the plan by :
    (*a*) Education and publicity.
    (*b*) Demonstration.
    (*c*) Local community endeavours.
    (*d*) Legislation.

Finally it must be stressed that as progress occurs, so modifications in the plan must be adopted. Planning must be a continuous process, always ahead of development.

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Population Trends and Their Agricultural Implications

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One of the most notable features in world history of the last two centuries has been the marked increase in population. The increase in world population between 1650 and 1933 is given by Carr-Saunders[3] as follows :

	1650. (Million.)	1933. (Million.)
Europe	100	519
Asia	330	1,121
Africa	100	145
America	13	262
Oceania	2	10
	545	2,057

This enormous increase in the last three centuries has been due, chiefly, to the saving of lives resulting from improved living conditions and advances in medical science, while the level of fertility has been maintained. Thus with *no increase* in fertility there was, until recent years, an increase in the number of surviving infants, the number of married women and consequently the number of families.

So accustomed has the world become to this population increase that it was expected to persist with its accompanying prosperity due to expansion. Now the outlook is changed largely as a result of the publications of Kuczynski, Carr-Saunders and Charles within the last fifteen years or more. The rate of population increase has been steadily decreasing for some time now in most countries and the indications are that it will soon cease altogether, the population becoming stationary followed by decline.

Two considerations afford an explanation of the forecasts of population decline : (1) The life saving factor has now almost reached its limit and is no longer a potent force ; (2) there is a decline in fertility.

The total number of births did not decrease for some time in western Europe and Australia owing to the increase in the number of mothers. This position could not be maintained for long, so that in 1903 in England and in 1914 in Australia a fall in total numbers became apparent.[5]

Thus the difference between total births and deaths (crude birth and death rates) at any time, while giving the natural increase, tends to give a false idea as to the reproductivity of the population, since the rates fail to take into account age and sex composition. The age composition of the Australian population is at present " abnormally " favourable to a high birth-rate (owing to the large proportion of women in the reproductive ages) in comparison with a theoretical " normal " age composition of a stationary population. The small number of oncoming children, however, will soon alter the disposition of the age groups, resulting in a larger proportion of older age groups and a smaller proportion of the reproductive ages.

In this paper I propose to make a brief resumé of the facts, with particular reference to the effect of the changed outlook on the agricultural situation in Australia.

The New Technique.

With the assistance of a new technique developed by Kuczynski,[9] it is now possible to estimate population trends far more accurately than in the past. This technique takes into account the age and sex composition of the population as well as mortality rates, and makes the assumption that births will be proportional to the female population which is within the reproductive ages, that is between the ages of 15 and 50. The masculinity of the population and the number of male births are ignored in the calculation.*

The term *net reproduction rate* (as distinguished from the *gross reproduction rate*) has been applied to the figure resulting from the new method of calculation. The gross reproductive rate does not make allowance for specific mortality rates, so that a G.R. rate of *one* will only indicate that a population is replacing itself if mortality is nil. Nevertheless, before 1890 this rate was falling in three countries, namely, U.S.A., France and Ireland. In the last century, countries within the sphere of European civilisation have also shown a falling rate.[3] The decline in this rate has been mainly due to a decline in the specific fertility rates.

The net reproduction rate traces the history of 1,000 girl babies as they grow and pass through the reproductive period, allowing for deaths on the way (specific mortality rates) and by applying specific fertility rates traces the number of girl babies they leave behind them at each year of age (or group of years). It might be noted that fertility of the female population has been found to be different in the different age groups,[14] being lower towards either age extreme of the reproductive period.

The summation of these age group totals of female infants divided by 1,000 equals the net reproduction rate, which gives a true picture of the tendency of the population to replace itself or not.

If this rate is unity, disregarding immigration and war effects, the population will be exactly replacing itself. Naturally this figure is lower than the G.R. rate; e.g. for England and Wales, 1934–36, the respective figures were 0·76 compared with 0·87.

The figure given for England and Wales means that the population is declining at the rate of 25 per cent. per generation, which is usually taken as about 30 years.

Population Trends.

Australian Population.

For Australia, Wolstenholme[14] shows a steady decline in the net reproduction rate from 1·539 in 1911 to 0·940 in 1935, i.e. a fall of some 31·5 per cent. based on the mortality rates of 1932–34, and he has calculated a fall to 0·69 by 1963.

Wolstenholme has made three population predictions for Australia. For estimate No. 1 the assumption is made that no further immigration takes place and that natality and mortality remain throughout the century at the 1932-34 level. For estimates Nos. 2 and 3, natality is assumed to take a steady downward movement, reaching 0·69 by 1963. Immigration is assumed to take place at the high level of pre-depression years and be maintained throughout in estimate No. 3. For all estimates the 1932–34 mortality rates have been employed.

* Wolstenholme points out that possibly the masculinity of the population may have to be considered.

Summary of the Results of Wolstenholme's Calculations.

Estimate No.	Maximum Population.	When Reached.	Population by Year 2003.	Rate of Decline by the End of the Century.
1	7,875,000	1977	7,632,000	0·18% per annum
2	7,420,000	1957	5,513,000	1·1% ,, ,,
3	8,940,000	1981	8,462,000	0·36% ,, ,,

It is pointed out that the N.R. rate of 0·69, assumed to be reached by 1963, is not much lower than the rate of 0·734 experienced in England in 1933, and might reasonably be expected to eventuate in the absence of any definite action towards encouragement of births.

Future reductions in mortality should partly offset the decline in natality, but if mortality were entirely eliminated among those who had not yet completed their reproductive life, it would increase reproductivity by only 10 per cent.

Wolstenholme also shows that an immigration flow of 40,000 a year will have little effect in stemming the decline. It would require an immigration rate of 0·78 per cent. of the total population per annum in order to stop the ultimate population decline.

So far as the effect of the present world conflict on the Australian trend is concerned, it would seem to hasten the coming decline rather than otherwise. The effect of war casualties among the younger sections of the population will tend to produce a sudden drop in natality which may be maintained for some time.

World Population.

The decline in the birth rate now showing seems to have gained momentum first in France and England, and to have spread more or less rapidly to other countries.[6]

Carr-Saunders[3] gives the following table of net reproduction rates for the world, taken from Kuczynski.

	1921.		1933.
England and Wales	1·087		0·734
Denmark	1·186		0·91
France	0·977		0·82
Germany	0·924		0·70
Sweden	1·058		0·73
European Russia (1896)	1·65	(1928)	1·7
U.S.A. (1920)	1·14	(1930)	1·08
Australia (1920)	1·339	(1930–33)	0·976
New Zealand (1911)	1·357		0·978

Kuczynski[10] divides the world population into three groups:

(1) Soviet Russia, with nearly 175 million inhabitants. The net reproduction rate is probably as high as it ever was, since mortality has decreased at least as much as fertility.

(2) Southern Europe and Poland, Lithuania and Canada, likewise with nearly 175 million inhabitants. The net reproduction rate in each of these countries is less than half as high as in Russia, and in some cases is very low.

(3) Western, Northern and Central Europe, the U.S.A., Australia and New Zealand, with about 370 million inhabitants—the population no longer reproduces itself.

If fertility and mortality rates remain as they were in 1933 in western and northern Europe the population, which is now about 193 million, would reach a maximum of about 196 million in the late 1940's and by the year 2000 would be reduced to 150 million. There is every indication, however, that the rate of fertility will not remain at the 1933 level but will continue to fall, and give a still lower population by the end of this century. The spread of family restriction to countries which are not yet showing a net reproduction rate below unity will still further reduce population.

Carr-Saunders and others have shown that while economic and social factors are the ultimate causes, birth-control measures are chiefly responsible for the reduction in family size, and it seems reasonable to expect that this practice will spread. The *average* number of children per family will have to increase from the present figure 2 to at least 3 to maintain the population. Further, the longer the N.R. rate remains below unity the greater will the average size of the future family have to be in order to secure stability. The changing age-composition of the female population will become progressively less favourable to a high birth-rate, and the decline will become cumulative.

The entire population will tend to become older which, in turn, will lead to a higher death rate. To offset this, a higher N.R. rate will be necessary to maintain the population in the future.[13] Harrod[6] thinks that by 1980 the N.R. rate necessary to stabilise a population would have to increase to nearly double the present figure, taking all factors into account. However, the fact emerges that within the next 30 or 40 years it seems inevitable that the population of a great many countries, including Australia and Great Britain, will become stationary or start to decline.

In Australia, a certain population decline has already commenced and unless some definite action is taken with the object of trying to stabilise the population at some future time the predicted changes will almost certainly become cumulative.

J. M. Keynes[8] has stated that " the time has already come when each country needs a considered national policy about what size of population, whether larger or smaller than at present, or the same, is most expedient. And having settled this policy we must take steps to carry it into operation."

Agricultural Implications.

In order to discover the agricultural implications, we might ask what will be the effects of the changes upon the national income, upon consumption and upon production generally, and rural production in particular in Australia. The future is so uncertain, however, that it is difficult to make accurate predictions. The changes will be somewhat gradual at first, with final decline many years hence (this latter will only affect long range policies). However, the changes are now in progress and will be showing their effects all too soon.

National Income.

In so far as the decline in population numbers may result in a greater share of capital equipment (already created) per head, there may be a tendency to an increase of the national income. To offset this, Madgwick[11] points out that as we have not yet reached the point of diminishing returns for all the factors of production, a decline in population numbers will tend to produce less per head and so reduce the national income unless we can look forward to increased export trade which, on the basis of the population trends, seems unlikely. The ageing of the population will tend to reduce the efficiency of production, which may also tend to reduce the national income.

Owing to the effects of contraction, investment will become more hazardous and economic fluctions will tend to increase. All this, and other factors, will probably

lead to increased unemployment unless special counteracting measures are taken. There is no need to enlarge upon the adverse repercussions both direct and indirect that this would have upon the rural industries.

Consumption and Demand.

Thus, if on the balance there is a reduction in the national income in Australia, there will not be much, if any, increased internal consumption per head, while the subsequent decline in population will reduce total consumption. Primary producers will be vitally concerned with any alterations in the demand for their products. While population is only one factor affecting demand, it would seem to be a very important one, since the changes will be almost worldwide. Especially is this so since for many years the whole economic outlook has been influenced by an increasing population with an increasing demand. Furthermore, with the advance of science we expect that rural production will increase.

It seems inevitable that eventually there will tend to be a drop in demand for agricultural food products because of reduced numbers, and any increase in the standard of living here or overseas would tend rather to increase the demand for luxury goods. It may be argued that fresh markets may be found in the East amongst countries with possibly an increasing population, but this would be doubtful if " economic nationalism " were to persist.

It may be that after the war there will be a shortage of foodstuffs, but this may be a purely temporary phase. If it led to stimulation of agricultural production it might eventually make the position worse, unless there is some return to freer international trade.

The ageing of the population here and abroad will have the effect of altering the nature of demand, since a larger proportion of older people will be demanding more goods for comfort. Quality will become more important than quantity; hence science will be of great assistance if only the producers will take advantage of it.

It seems unlikely that we can look to immigration as a means of increasing our total numbers or the numbers of young people, owing to the changing age composition. Forsyth[5] has shown that by 1950 in England the shrinkage of numbers of young people will be seven times as great each year as was the loss by emigration before the depression, and even now there is no significant surplus of young people in England or European countries. In so far as the altered nature of demand is met by an effective change-over of production, there may not be any very great hardship. Nevertheless the agriculturalist may also be responsible for contributing to the number of the unemployed during the course of the necessary changes.

The Exchange Question.

The unemployment problem may be somewhat offset by Australia engaging in more secondary manufacturing, especially if we would be unable to purchase on our previous scale from Great Britain, in exchange for foodstuffs which she would no longer require owing to the population decline. But there is a danger here that by cutting off our imports through excessive development of secondary industries, we may further jeopardise the export of our rural products by preventing potential purchasers from acquiring Australian exchange credit. Certainly it seems that we shall have to write off a certain amount of rural production, but provided we can strike some balance between primary and secondary industries and, given improved international relationships after the war, this may not be excessive. Any effective change over to production of more marketable products would also help to iron out some of the writing off difficulties.

General Conclusions.

Whatever may be the ultimate effects, it does seem that the time is opportune for agricultural scientists to start to take stock of things and re-examine the advice they are giving to the man on the land. Any long-range policies, such as long-term loans, should be carefully reviewed in the light of possible writing off of some primary production. It has been said that production may automatically adjust itself to these new circumstances. Adjustment, however, usually brings many pains and breeds much discontent in the community. If it is within the power of the scientist to bring adjustment more equitably and so allay the pains of change, he should do so. It would seem that the agricultural scientist and the economist are to be drawn closer together in a more active cooperation, since the whole question of the change is complex and largely bound up with an unknown economic future. The facts would appear to call for much research and careful thinking. By this means it may be possible to advise rural producers as to more profitable lines of production to undertake, having regard to the likely changes in demand conditions. Agricultural potentialities surveys should provide useful data for altering the structure of production to meet the new conditions.

The changes may lead to a greater degree of State control and planning. The war, too, may result in a spirit of greater cooperation. If these changes do appear, we can conclude that they will tend to make the problems of adjustment easier. The changes about to take place in the next generation will raise serious problems for Australia unless we can show sufficient social resourcefulness and adaptability to solve the various problems of adjustment.

Acknowledgments.

I wish to thank Lieut.-Col. Dr. R. B. Madgwick, who offered helpful criticism and gave valuable advice as to the method of approach in preparing the paper. I am also indebted to Mr. J. A. La Nauze, M.A., for helpful suggestions and criticism.

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The Use of Chlorine in the Near-Sterilisation of Milking Machines*

By

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The milking machine is the most delicate of dairy utensils, and requires methodical and regular cleaning. Bacteriological analyses have shown that milking machines may be so cared for as to render them practically free from bacteria of all kinds, making it possible to draw milk which contains few bacteria other than those originally present in the udder of the cow.

It is essential that the use of milking machines be not discouraged. Iowa workers have shown that the use of a milking machine saves about one-half the labour required for milking a herd of 20 to 25 cows. Greater saving in labour occurs in larger and higher producing herds.

Historical.

Early investigators recognised that hot water possesses certain advantages as a sterilising agent for milking machines, and a standard procedure was developed for machine treatment consisting of a cold water-hot soda water-boiling water treatment. This treatment was a considerable advance in cleansing technique and where it was carried out thoroughly, good results were obtained. However, several users failed to realise the importance of using *boiling* water, with the result that bacterial reduction was not sufficient to provide milk of the required standard of quality. This led to the necessity for a revision of treatment methods. At the time, steam sterilisation was not practicable because the rubber parts of the milking machine soon perished under the drastic heat treatment. Consequently a number of investigators turned to the use of chemicals for milking machine sterilisation and substances such as boracic acid, lime, formaldehyde, hypochlorites of sodium and calcium, chloramines, " gold dust " solution, brine, copper sulphate, vinegar, acetic acid and montanin were tried. Of these, lime and brine were popular for a time, but the chlorine derivatives quickly established themselves as being the most useful. Lois Wing,[1] of Cornell, was the first worker to call attention to the usefulness of chlorine derivatives, and her work was quickly followed by experiments by Moack,[2] Reudiger,[3] Ruehle, Breed and Smith,[4] Bright,[5] Robertson, Finch and Breed,[6] Burgwald,[7] Fisher and White.[8] Most exhaustive experiments were conducted by Lochhead and Johns[9] of Canada during 1927–28. As a result of these investigations the use of chlorine derivatives was widely practised with good results.

In Australia, the use of steam sterilisation has been advocated for milking machines of recent years and excellent results are being obtained with this method. Small steam sterilising units have become available on the market, and the heat resistance of the rubber parts of the milking machine has been greatly increased to meet the requirements of steam treatment.

* Portion of a thesis presented for the degree of Master of Science in Agriculture of the University of Queensland.

However, since the steam is applied to the machine unit at the conclusion of the cleaning process carried out at the end of the milking, its use alone is not as effective as a combination of steam and chemical treatment or chemical treatment alone.

The present paper shows the results obtained by the author with the use of chlorine solutions in treating a milking machine during the height of the summer season of 1931 and 1932 and during the winter months of May and June, 1935.

Methods.

The experimental work was conducted at the Queensland Agricultural College, Lawes, using a Warren Farmer milking machine. This machine is considered representative of milking machine types in use in Australia in that the general design of the teat cups, rubbers and milk line closely resembles other modern makes of milking machines. A four-unit machine was used in the experiment and the daily treatment prior to the experiment was as follows: Immediately after milking two gallons of cold water were drawn through the machines, followed by a hot sodium carbonate solution, and finally two gallons of water, as near to boiling as the proximity of the source of heating would allow. The teat cups were hung up in the bails between milkings. On Monday of each week the machines were dissembled, cleaned, any unsatisfactory parts replaced, and assembled again before the evening milking. This procedure was continued throughout the experiment.

Owing to variations in bacterial counts obtained from milk withdrawn aseptically from the udder, it was considered that the use of machine-drawn milk as a basis of the counts obtained from the various treatments was not sufficiently accurate. For this reason a sterile physiological salt solution was chosen. Ten litres of this solution were drawn through the machines each time and the solution was caught in a bucket, previously sterilised in a hot air steriliser. The salt solution was sterilised by boiling for one hour. Periodical tests showed it to be completely sterile. Both the salt solution and the bucket were sterilised between 4 and 5 p.m. and 8 and 9 a.m. and allowed to cool until required. A 100 ml. sample of the solution after passage through the machine was used to make dilutions of 0·1 ml., 0·01 ml., 0·001 ml. and 0·0001 ml. of the original sample as necessary. One ml. of each dilution was plated out on dextrose-lactose agar (after Robertson[10]) plates in triplicate. The pH of the medium was adjusted to between 6·8 and 7·0. The dilutions were made and plated out within half an hour of sampling.

The plates were incubated at a temperature of 21° C. for four days and for an additional two days at 37° C.

Throughout the experiment control tests were conducted once in each four trials. By this means a basis of comparison was always available and any change in the conditions noted.

Ruehle, Breed and Smith[4] decided that with proper care of utensils and reasonably good dairy conditions the germ content of fresh milk from cows with uninfected udders ought not to exceed 10,000 per ml. In these experiments a count lower than 25,000 per ml. was considered satisfactory, as the American workers used a bucket type of machine without a common milk line.

The Control Treatment.

This treatment was the cold water-hot soda water-boiling water procedure, and was used once in every four tests. The counts obtained from this treatment, together with the maximum daily temperature, were as follows:

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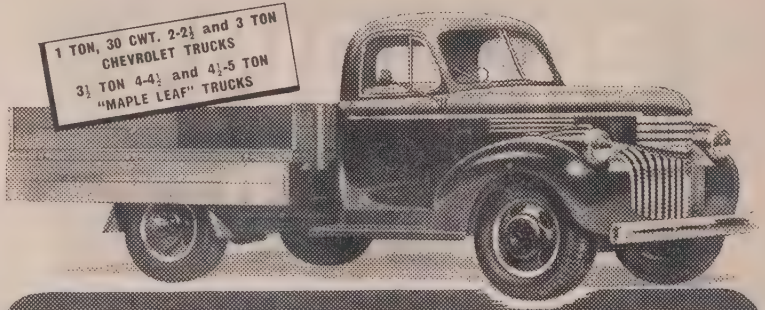

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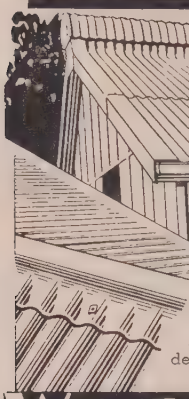

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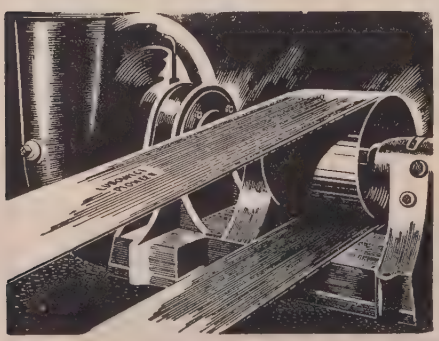

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TABLE 1.

Bacterial Counts and Temperatures in the Control Treatment (Cold Water–Hot Soda Water–Boiling Water) of a Milking Machine.

Date.	Temp. °F.	Bacterial Count per ml.	Remarks.
November 25 ..	83·0	109,000	
December 7 ..	75·0	110,000	
December 31 ..	86·0	34,496	Followed a treatment of Germ X.
January 2 ..	86·0	16,550	Both ends of milk line closed during day.
January 4 ..	97·0	85,000	
January 6 ..	90·2	91,240	
January 8 ..	94·5	50,000	
January 10 ..	97·0	46,250	
January 12 ..	71·8	165,000	Slight shower in night. Mainly "pin-point" colonies.
January 18 ..	83·0	27,600	Machines taken apart and washed during day.
January 23 ..	90·0	19,500	
January 24 ..	63·0	58,300	
January 25 ..	94·0	49,600	

The average count of all representative tests was 67,532 bacteria per ml. It will be noted that at the commencement of the experiment the average count was in the vicinity of 100,000 bacteria per ml. As the experiment proceeded, this count was considerably reduced. This probably was due to the effect of the use of the chemical sterilisers which gradually killed out resistant types leaving only a reduced flora to develop.

Treatments Involving the Use of Chlorine Derivatives.

The chlorine derivatives in use are as follows :

1. Calcium hypochlorite, commercially known as bleaching powder or chloride of lime.
2. Liquid sodium hypochlorite, sold under various trade names such as B-K, Germ X, etc.
3. Solid sodium hypochlorite, sold under the name of Diversol. The sodium hypochlorite is combined with an alkaline phosphate in crystalline form.
4. Chloramine-T, sold in powder or tablet form under such names as Santamine, etc.

All of the chlorine sterilisers have one property in common ; namely, they all contain a percentage of chlorine that kills the bacteria. The power of chlorine solutions to act as disinfectants depends, firstly, on the available chlorine content and, secondly, on the chemical and physical properties of the material to be disinfected. The active chlorine is continually escaping from most of these sterilisers. Organic matter accompanied by high temperatures results in almost instantaneous and complete loss of chlorine. Organic matter, such as milk residue, rapidly deteriorates chlorine solutions by using up the chlorine in oxidation. After all the chlorine is utilised, the disinfectant properties of such a solution are nil and bacteria may even multiply in it in great numbers.

Different commercial products vary in regard to the stability of the chlorine, some losing their strength much faster than others. Calcium hypochlorites are very

unstable ; sodium hypochlorites vary. The chloramines, prepared by the interaction of sodium hypochlorite with ammonia in the presence of a colloid, are more stable.

Immersion of Teat Cups in a Chlorine Solution between Milkings.

In the first test, a solution of sodium hypochlorite of a strength of 200 p.p.m. of available chlorine was used in combination with saturated brine to act as a stabiliser. This latter was insufficient to maintain the chlorine strength which had to be reinforced twice daily. The teat cups and rubbers were removed from the unit daily and immersed in this solution, contained in an earthenware crock, between milkings. Difficulty was experienced with the ball valves of the Warren-Farmer machine with this treatment as salt particles prevented them from working effectively. In addition it was necessary to pass at least a gallon of water through each unit before milking to remove the salt. The exterior of the teat cups was slightly corroded with the treatment. The average count for this method was 30,994 bacteria per ml.

In order to attempt to stabilise the chlorine, a solution of Santamine and 10 per cent. brine was used. The average count with this method was 53,320 per ml.

Use of Chlorine Derivatives as a Rinse.

Several chlorine derivatives were used as rinses, either to replace the final hot water of the control treatment or as a preliminary rinse immediately preceding each milking. This latter method proved the more efficient. The rinses were of varying strength, the water used being a good quality rain water and the solutions, when made up, were always sterile. Two gallons of the solution were made up, allowing half a gallon to be drawn through each unit. The rinsing method has the advantage that the solution is used immediately after preparation with no appreciable loss of available chlorine. It also requires less equipment and less handling of the machine parts. The results are summarised in Table 2.

TABLE 2.

Relative Efficiency of Various Chlorine Preparations used as Rinses for a Milking Machine.

Chemical.	Strength of Available Chlorine. p.p.m.	Rinse Before or After Milking.	Average Bacterial Count per ml.
Hypozone	200	Before	1,146
Commercial sodium hypochlorite ..	200	Before	1,449
	200	After	24,615
Germ X	200	Before	157
B–K	200	Before	44
H.T.H.	200	Before	73
Calcium hypochlorite	200	Before	159
Santamine	200	Before	14,813

A study of Table 2 will show that the chlorine rinses were infinitely more effective as a whole than the control treatment which averaged 67,532 bacteria per ml. The data also show that the use of chlorine as a final rinse after washing is not so effective as when used before milking. This is understandable, as the milk line and teat cups are exposed to contamination between milking.

The final series of treatments conducted successively during the winter of 1935 yielded interesting data, presented in Table 3.

TABLE 3.

Data for Successive Daily Treatments of a Milking Machine with Various Chlorine Preparations.

Date.	Period of Day.	Treatment.	Solution Strength as p.p.m. Available Chlorine.	Bacterial Count per ml.
6.5.35	p.m.	Control.		2,800,000
7.5.35	a.m.	,,		2,080,000
7.5.35	p.m.	,,		3,500,000
8.5.35	a.m.	,,		1,800,000
8.5.35	p.m.	H.T.H.	80	130,000
9.5.35	a.m.	,,	60	56,800
9.5.35	p.m.	,,	39	120,000
10.5.35	a.m.	,,	55	16,100
10.5.35	p.m.	,,	60	31,100
11.5.35	a.m.	,,	50	43,300
13.5.35	p.m.	,,	50	120,000
14.5.35	a.m.	,,	80	1,000
14.5.35	p.m.	,,	105	1,200
15.5.35	a.m.	,,	105	80
15.5.35	p.m.	,,	105	150
16.5.35	a.m.	,,	105	250
16.5.35	p.m.	,,	99	750
17.7.35	a.m.	,,	117	30
20.5.35	p.m.	,,	220	4,480
21.5.35	a.m.	Ca hypochlorite.	165	60
21.5.35	p.m.	,, ,,	259	4
22.5.35	a.m.	,, ,,	240	1·5
22.5.35	p.m.	,, ,,	312	9
23.5.35	a.m.	,, ,,	294	Nil
23.5.35	p.m.	,, ,,	240	3
24.5.35	a.m.	H.T.H.	240	7
27.5.35	p.m.	Control.		2,210,000
28.5.35	a.m.	,,		930,000
29.5.35	a.m.	,,		1,120,000
30.5.35	p.m.	Na hypochlorite.	269	7
31.5.35	a.m.	,, ,,	202	7
4.6.35	p.m.	,, ,,	240	470
5.6.35	a.m.	,, ,,	115	6
5.6.35	p.m.	,, ,,	50	75
6.6.35	a.m.	,, ,,	69	197
6.6.35	p.m.	,, ,,	61	1,560
7.6.35	a.m.	,, ,,	52	480
7.6.35	p.m.	,, ,,	52	980
10.6.35	p.m.	,, ,,	107	No count made
11.6.35	a.m.	,, ,,	100	4
11.6.35	p.m.	,, ,,	99	14
12.6.35	a.m.	,, ,,	97	2
12.6.35	p.m.	,, ,,	113	400
13.6.35	a.m.	,, ,,	205	Nil
13.6.35	p.m.	Control.		350,000
14.6.35	a.m.	,,		50,000
14.6.35	p.m.	,,		200,000

A summary of the control tests reveals counts ranging from 3,500,000 to 50,000 organisms per ml. This variation can be accounted for by studying the positions of the treatments. The first four tests, with an average of 2,500,000 per ml., were made prior to any chlorine treatment and reveal the actual condition of the machine at the commencement of the series of tests. The next lot of three control tests gives an average count of 1,400,000. These were obtained from a machine which had not been treated with chlorine during a week-end, allowing the normal flora to

develop freely again. The final series of three control tests followed hard on strong chlorine rinses, and the average count of 200,000 was recorded. This lower count can be attributed to the effect of the preceding treatment with chlorine in killing out a number of organisms, resulting in a lessened rate of multiplication in the time available.

A study of the effect of chlorine solutions of varying strength will show that a 50 p.p.m. solution exerts a reasonable measure of control of milking machine flora and, following after treatments of higher chlorine content, it is quite effective. Solutions of 100 p.p.m. are most suitable, while solutions of 200 p.p.m. (or greater chlorine content) practically sterilise the milking unit.

Practical Considerations.

Under practical conditions the choice of the chlorine derivative is important. The most stable are the chloramines, the most easily used are the sodium hypochlorites, and the cheapest are the calcium hypochlorites. From a consideration of all three, ordinary commercial calcium hypochlorite or bleaching powder is preferred by the writer. Its cost is less than one-halfpenny per day for two milkings, whereas sodium hypochlorite costs 5d. per day, and chloramine 1s. per day.

The loss of chlorine can be overcome to a large extent by frequent purchase of small amounts—a 12 lb. earthenware jar is recommended. The sediment obtained in solution is unimportant, as it is not sucked through the machines.

The solution of 50 p.p.m. of available chlorine is satisfactory under fairly clean conditions, but would be improved by a weekly treatment of a stronger solution. Under practical conditions of loss of available chlorine and error on the part of the user, a 100 p.p.m. solution is preferable as this gives a margin of safety.

Stronger solutions may impart a slight chlorine taint to the milk or cream during the periods of low production, but under conditions of normal milk flow no trouble is incurred. Where a chlorine taint is apparent during low production, a cold water rinse would remove the trouble.

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Shrub Pastures Under Low Rainfall

AN EXPERIMENT ON GRAZING MANAGEMENT

By

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The chief pastures of the pastoral areas in South Australia, receiving less than 10 inches of mean annual rainfall, are those dominated in their natural state by saltbush (*Atriplex vesicarium*) and bluebush (*Kochia sedifolia*). Both of these perennial bushes are morphologically and physiologically adapted to withstand rainless periods of long duration.[5] During good seasons numerous annuals and ephemerals develop, but with the onset of drought these disappear and the perennial bushes then provide reserves of fodder and protection to the otherwise bare soils.

Unfortunately, much degeneration of the stands of saltbush and bluebush has occurred since the letting of the country on pastoral lease ; in 1936 it was estimated[4] that only 10 to 25 per cent. of the original bush cover remained. The seriousness of the consequences, including wind erosion of soils in drought years and general insecurity of the industry, have been emphasised by Ratcliffe[4] and by others. It is now widely recognised that mismanagement, chiefly overgrazing by sheep, is to blame for the widespread depletion of a limited resource of plant capital.

As it is exceedingly difficult to re-establish perennial bush on denuded soil in pastoral country, under the conditions of low and variable rainfall, there is a need for methods whereby the remaining areas of saltbush and bluebush may be preserved, and at the same time utilised without serious loss of production. The only previous investigation on the reaction of saltbush or bluebush to stocking is that of Osborn, Wood and Paltridge[2] who studied the effect of sheep on saltbush by means of line transects from watering places on Koonamore and adjacent stations. They found that saltbush benefited under moderately heavy grazing and that intermittent heavy grazing improved both the vigour of the bush and the establishment of seedlings.

The present paper discusses the design and technique of an experiment to examine the effects of varying intensity and incidence of stocking by sheep on pastures dominated by bluebush (*Kochia sedifolia*).

Description of the Area.

The area selected for experimental purposes is part of Yudnapinna Station, situated 50 miles north-west of Port Augusta. The mean annual rainfall at the station over a period of 50 years is 7·5 inches, but the most significant features of the rainfall are its extreme variability, ranging from 18·08 inches in 1922 to 2·36 inches in 1928, and the sporadic nature of the rains. Under the present policy of conservative stocking, the property carries an average of 22 sheep per square mile over the whole area of 1,390 square miles.

Crocker[1] has described the principal soil and vegetation relationships, the chief vegetation association being myall (*Acacia Sowdenii*)-sandalwood (*Myoporum platycarpum*) tree steppe with a lower stratum of bluebush or saltbush. The present grazing trial is located on a typical area of this tree-shrub steppe. A survey prior to final choice of the site revealed a high degree of uniformity both of soil and vegetation. The latter consists of an open association, with myall the dominant tree and bluebush the principal shrub. Although the dominant species is *Kochia sedifolia*, various shrubs, including additional *Kochia* spp. and *Atriplex* spp., occur

in small numbers. Following heavy rains, *Bassia* spp., *Erodium cygnorum*, *Tetragonia eremea*, *Enneapogon* spp., other grasses and herbage are temporarily prominent.

So far as was evident the vegetation has been practically unaffected by its previous stocking history.

Design of Experiment.

An experiment of this nature, to justify itself, must give results of more than mere academic value. In designing the experiment the practical application of possible results was kept well in mind, despite formidable difficulties in reconciling the practical viewpoint with scientific requirements.

It was realised at the outset that traditional methods of pasture experimentation, involving replicated small plots, were out of place owing to the low carrying capacity of the country. This made large plots of at least one-quarter square mile necessary, with consequent problems of yield measurement, and high costs of materials and maintenance. In view of the uniformity of the experimental area and the necessity for large plots, together with a comprehensive series of treatments, it was felt that replication was not feasible. As differences between treatments must be large to be of practical significance, however, the loss of replication was not considered serious.

Light, medium, and heavy rates of stocking under different systems of spelling were contemplated as treatments. It was obviously impossible to divide the year into the accepted four seasons and to spell plots at any of these seasons, since, because of the irregularity of the rainfall, the growing season may occur at any time in one year and at different times in separate years.

It is generally accepted that most damage is done to perennial bush by overgrazing during drought. Among pastoralists who practise spelling of their pastures there are two schools of thought as to the best time to rest paddocks. One school holds that heavy stocking may be practised in good years, provided stock are withdrawn at the onset of drought. The alternative viewpoint is that bush may be stocked moderately even during drought, provided paddocks are rested after a good rain, when, it is claimed, a vigorous recovery is made by the bush.

It seemed logical to base experimental rest periods on what appears to be the growth cycle of saltbush and bluebush in pastoral country. This cycle is characterised by a period of active growth after effective rains, followed by a term of stability in which no growth is made, but during which the leaves maintain their freshness. Finally, on the onset of drought conditions, there is a period of debility, during which the leaves wither and are shed.

The final form of the experiment provides for a control plot (ungrazed) and for three levels of stocking under each of the four systems of grazing, viz., grazed continuously, spelled following effective rains, spelled during drought, spelled during the intermediate period between cessation of growth and the onset of severe drought. One further treatment is included to compare the relative effects of bore and surface catchment waters on sheep and their grazing influences, as these are points in which the station is vitally interested.

As sheep will graze over the whole of a paddock one-quarter square mile in area, (whereas in paddocks of 10 square miles or more served by one water, the portion more than three miles distant from water is rarely grazed), rates of stocking have been made higher than is usual in practice. Rates equivalent to 24, 48, 72 sheep per square mile per annum were adopted to represent light, medium and heavy stocking respectively.

The layout of the experiment is shown in Figure 1. The two spelling paddocks accommodate sheep when they are removed from plots that are being spelled.

Data will be recorded on the effect of the different types and intensities of grazing on the pasture, the live weights and wool production of sheep.

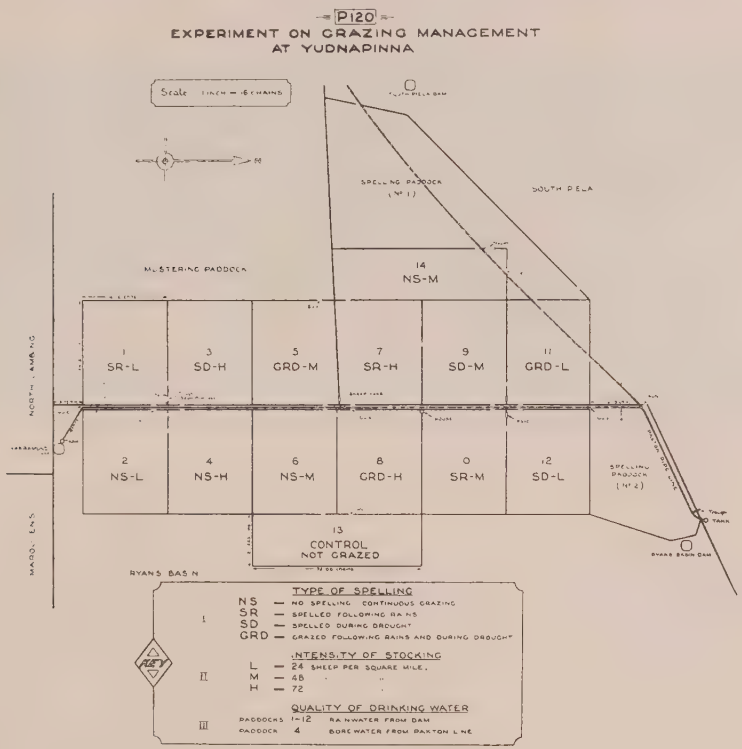

Figure 1.
Plan of Experiment.

Measurement of Forage Production.

The problem of measuring the effect of grazing on shrub pastures over such extensive areas presented considerable difficulty. Methods based on ground cover do not enable estimates to be checked impersonally, whilst the relationship between density and herbage yield is unsatisfactory. Determination of herbage production by clipping and weighing plants on sample areas is totally inadequate on such large plots.

The method of direct weight estimates described by Pechanec and Pickford[3] appeared to offer a satisfactory means of overcoming the problem. The method relies on the visual estimation of the edible quantity of bush on individual plants within the sample area so that the gross herbage for stock grazing can be assessed. A preliminary trial of this method on the experimental area suggested that with slight modification it would prove eminently suitable. The principal advantages of the method lie in the number of samples that can be dealt with in a reasonable time and the fact that it is possible to check personal errors by actually clipping and weighing plants. As finally adopted, the technique required simple equipment (Figure 2), including a small spring balance, a pair of shears, a small tarpaulin two-feet square, a chain and marker for delineating circular plots, and cards for recording.

Figure 2.
Type of pasture, sample area and equipment for making weight estimates, Yudnapinna Station.

At the beginning of a series of estimates, some time (perhaps two or three days) is spent in obtaining standards for different species. This consists of estimating edible herbage in terms of 10 to 100 gramme units, according to species, then clipping and weighing the estimated samples. The edible portion is defined at the outset by observing the degree to which sheep graze different species under conditions of heavy stocking. Actual estimates are made on circular sample areas which provide for rapid working, and the larger number of samples of this type that can be handled outweighs the disadvantage of the circular unit compared with a rectangular sampling area. Sample areas of one-hundredth of an acre were found by trial to be of suitable size for the particular type of pasture under review. A note is made of the number and condition of different species, the weight of edible herbage on each plant is estimated individually and the total for the sample area recorded.

Prior to morning and afternoon estimates, half to one hour is spent on checking by estimating, clipping, and weighing the herbage on bushes outside the sample areas. From 16 to 32 samples of one-hundredth of an acre can be covered by one estimator each day. Weights estimated by different individuals are strictly comparable as the system of frequent checks eliminates personal errors to a remarkable degree. This is shown by an analysis of check estimates carried out on four bluebush plants by two estimators every morning for twenty mornings, taking the actual weight of edible herbage per bush as 100. The mean of the estimates by two individuals on any one day differed significantly from the actual weight of cut material on only three days, while there was a significant difference between the daily mean estimates on only four days. Additional checks are made, on days when discrepancies in the trial estimates are detected, before work is commenced on the sample areas. Taking the mean values for 80 bushes, there was no significant difference between estimator A (100·96), estimator B (99·29) and the actual mean value of the population (100).

Sixty-four permanent sample areas of one-hundredth of an acre per plot, arranged in a grid pattern to ensure representativeness, give a standard error of sampling of

10 per cent. or less, which is considered satisfactory for this type of experiment. A permanent peg, three feet high, is used to mark the centre of each sample area.

Interpretation of Results.

It is planned to make one complete estimate of yields on all plots each year. The experiment is necessarily of a long term nature, since it will take some years for differences due to differential stocking treatment to become manifest, and in addition the trial must extend for a number of years to cover an average run of seasons.

Considerable seasonal variation in quantity of edible herbage is likely to occur during the interval between yearly estimates and it would involve a great deal of additional work to keep account of these short term effects. On the other hand, the experiment is designed to examine in particular the long term trends due to different grazing treatment. The perennial bluebush should be an admirable long term indicator under a system of yearly records. As a matter of routine, however, estimates are also made of such annual herbage as exists at the time of making the estimates.

Two complete estimates, at an interval of six months, were made before grazing started on the plots at the end of April, 1941. The first was carried out under drought conditions and the second following heavy rains earlier in the year. Later it may be possible to correct plot yields by an analysis of co-variance using these data. Photographs will be taken from time to time at two permanent points within each plot to provide visual evidence of treatment effects. A complete series was obtained before the experiment began.

The magnitude of the experiment may be realised from the fact that it covers $4\frac{1}{2}$ square miles of country and that 26 miles of fencing are involved. Results may not be immediately translatable into station practice but there are good grounds for believing that certain principles of grazing for sheep pastures in low rainfall areas may be established. It will then be necessary to test the application of these principles to full-scale station conditions.

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TECHNICAL NOTES

VARIETAL RESISTANCE TO FOOT-ROTS IN WHEAT.

The control of the group of diseases classed as foot and root rots presents one of the most difficult problems facing present day agriculturalists. In Victoria, the very wide incidence of the disease and the relatively high infections that are occasionally found in crops (Millikan—unpublished data) make this probably the most serious disease of wheat at present in this State.

Although various methods of cultivation and rotational systems have been credited with a reduction in the incidence of the trouble from time to time, no specific recommendations for adequate control can yet be made with any degree of confidence. Likewise, varietal resistance has proved of little value for the reason that it has

not been possible to demonstrate effectively that degrees of resistance occur within the present-day varieties.

In view of the general occurrence of differential varietal resistance to disease, it is difficult to believe that some degree of resistance does not occur in the case of foot-rots. Possibly this is due to the difficulty of artificially inducing high infections under field conditions where large numbers of varieties can be conveniently tested.

It is the purpose of the present article to show that under certain conditions where a natural, high infection was experienced in the field, a considerable degree of differential varietal resistance to the disease was observed amongst the ordinary varieties grown. It is hoped that this may stimulate further work along this potential line of control.

In 1940, an unusually severe attack of foot-rot was apparent in wheat at the State Research Farm, Werribee. The climatic conditions in that year were such that growth throughout the year was below average, due to low rainfall. Heavy rain was received in September, but this was followed by further dry periods in October and early November. Grainless " white heads " appeared in large numbers in late October, and many heads showed premature drying-off with very shrivelled grain. Pathological examination of these revealed that foot-rot organisms were present in most cases, *Fusarium* spp. being the most prevalent. In view of the general severity of the attack, it was decided to obtain estimates of the relative resistance of a number of wheat varieties to the disease.

From an economic point of view, control of any disease is obtained when the ill effects of any given disease are reduced to negligible proportions. This does not necessarily coincide with complete freedom from infection. It was considered therefore that freedom from ill effects of the disease was the more desirable measurement.

Counts were made of the total number of heads in four half-chain rows per plot (between 1,200 and 1,600 in each plot), a separate tally being kept of those showing the aforementioned symptoms. The number of affected heads, expressed as a percentage of the total, has been used as the severity index. Although the number so obtained undoubtedly did not include all the diseased plants, it represented a fair measure of the severity of the infection. Subsequent observation one month later did not show any material difference in the number of affected ears.

A variability study of resistance was made on four varieties, Baldmin, Sepoy, Ranee 4H and Ghurka, each of which was present in four different trials which had been sown at different times in separate locations. Figures for the average severity index of each plot are given in Table 1.

TABLE 1.

Index Figures for Average Foot-rot Severity in Varieties of Wheat Sown in Different Trials.

Variety.	Location and Date of Sowing. (A) May 10.	(B) May 15.	(C) May 15.	(D) May 31.	Mean.
Baldmin	20·1	19·3	22·4	26·1	22·0
Sepoy	24·3	11·5	15·1	14·0	16·2
Ranee 4H	10·1	9·3	17·4	4·5	10·3
Ghurka	13·8	6·7	9·0	6·6	9·0
Mean	17·1	11·7	16·0	12·8	

The statistical examination of the figures, using the inverse sine transformation, gave the following analysis of variance:

	D/f.	Mean Square.	F Ratio.
Varieties	3	397	23·4++
Location	3	102	6·0++
V×L	9	51	3·0++
Within plot	48	17	
Total	63		

S.E. (mean of four plots)=1·03 (angular measure).

It is apparent, then, that the differences produced by variety, location (and/or time of sowing) and the interaction between these two are all significant (>1 per cent.) for the conditions studied in this examination. Moreover, it may be noticed that the variance for varieties is not only significantly greater than the variation within plot, but it is also greater (>1 per cent.) than the variety×location variance.

It is therefore evident that (*a*) varietal resistance has been demonstrated for these particular conditions; (*b*) different sites and/or times of sowing have produced a significant effect on the relative order of varieties in so far as severity index is concerned; and (*c*) the average over-all resistance of the varieties is, however, significantly greater than the variation due to effect (*b*).

In addition to the variability study, counts for a number of varieties were made on two half-chain samples per plot from each of four plots sown at different times and locations in the paddock. While it may be of interest to quote the figures obtained from the more important varieties studied, it should be remembered that they are for one season only in the Werribee district. Since Millikan (unpublished data) has shown that the fungal flora associated with the foot-rot complex vary considerably with season and district, the observations will have to be repeated before varietal resistance to the entire foot-rot complex can be tabulated with any degree of certainty.

Foot-rot Severity Index, Werribee, 1940.

	Per Cent.
Baldmin	21
Free Gallipoli	20
Quadrat	17
Sepoy	16
Pindar	13
Magnet	10
Ranee 4H	10
Ghurka	9
Regalia	8

It is noticeable that the varietal resistance as found at Werribee is not simply a function of the stage of development of the variety at the time of attack, since both early and late maturing varieties occur at either end of the table.

From these observations, it is evident that some degree of varietal resistance does occur under the conditions studied. Thus, even if it be impossible to obtain varieties that possess complete resistance, it should be practicable to utilise the more resistant types to breed wheats which have at least a considerable degree of tolerance to the disease.

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PALESTINE STRAWBERRY CLOVER (*TRIFOLIUM FRAGIFERUM* L.).

In southern Australia, perennial herbage legumes are limited for most practical purposes to lucerne, white clover and strawberry clover. During recent years, it has become evident that there is scope for a wider use of strawberry clover on neutral to alkaline soils of heavy texture, either under irrigation or where the supply of soil moisture in early summer is liberal.

Commercial strawberry clover (left) and Palestine strawberry clover (right) in association with Kikuyu grass, taken at equal distances from the camera, Meadows, S.A., in March, 1941.

The inclusion of strawberry clover in pasture mixtures has tended to be restricted by the marked inferiority of certain commercial types, which are fine-leaved, short and of low productivity.

In January 1929, one of the writers noticed a vigorous strain, apparently of the strawberry clover type, occupying a small plot at the Salisbury Experiment Station in Southern Rhodesia. The plants were then barely flowering, and it was arranged that seed should be collected and forwarded to the Waite Institute later in the year. Following establishment at Adelaide, yields considerably superior to those of commercial strawberry clover were obtained. Specimens were forwarded to Kew, where identification as *Trifolium fragiferum* L. was confirmed, and the strain has since been known as Palestine strawberry clover.

Advice received at Salisbury in 1929 indicated that a small quantity of seed had been collected in the Jordan Valley and brought back from Palestine by a Rhodesian soldier after the 1914-18 war. Further enquiry elicited the following statement from Mr. H. G. Mundy, Secretary, Department of Agriculture and Lands, Southern Rhodesia, written on 25th September, 1933.

"Some eight or nine years ago, I was informed by a Rhodesian settler who had soldiered in Palestine that a particular type of clover had been very much appreciated by cavalry horses when our army was camped in the vicinity of the Dead Sea. After a good deal of correspondence, we eventually secured a sample of this seed, which was then grown in Rhodesia for the following two or three years. Plots were laid down on the Salisbury Experiment Station in close proximity to plots of other clovers."

Between 1930 and 1935, samples of rhizomes and seeds were distributed from the Waite Institute, for trial purposes, to higher rainfall districts in South Australia and to other States. In general, favourable reports were received and enquiries were made as to possible commercial sources of the seed.

By 1935, the Palestine strain had become regarded as so much superior to the commercial varieties then available that in May of that year, two ounces of the seed were forwarded to N. J. McBain of Coonawarra, South Australia, with the suggestion that sufficient seedlings be raised to plant by hand several acres, as a source from which to build up an extended area for commercial seed production. This was subsequently carried out and the Palestine variety has been on the commercial seeds market since 1938.

In 1935, a comparative test was made of 24 samples of strawberry clover, under single plant conditions, on irrigated land at Wood's Point, S.A. Material differences were evident between samples of different origin, and five commercial types included in the test were all inferior to the remaining strains. Shearman's variety, the Palestine strain, types from irrigated pastures in Victoria, and from the Adelaide Parklands demonstrated a high capacity for production.

Sward trials were attempted at Wood's Point in 1936 and 1937, but conditions proved unfavourable for the species and none of the strains grew sufficiently well to ensure satisfactory tests.

In 1938, the main contrasting types, including those of greatest vigour, were established in small plots on swampy land at Meadows, S.A. The Palestine strain proved exceptionally vigorous from the outset, and by the end of the second summer had extended for a distance of four feet from the plot boundaries. During the 1940-41 summer, this strain, together with the Shearman's variety, had overrun the plots, suppressing to a marked degree the majority of the remaining strains. The Palestine strain appears to be capable of greater winter production than other strains, and although comparatively coarse and lax in growth-form, recovers well after grazing. It appears to be well adapted to swamp conditions.

Strawberry clover will grow in association with Kikuyu grass, and this combination has successfully reclaimed swampy land in the Meadows district. Mixtures of *Phalaris tuberosa* and strawberry clover also appear well adapted to heavy black soils (rendzinas) receiving good rainfall.

Attention has recently been paid to strawberry clover in the Pacific North-west of the United States, especially in the Yakima Valley of Washington State, where a productive type has appeared spontaneously and spread naturally under irrigation. The species is noted for tolerance to salt or alkali, provided the soil does not become dry. In southern Australia, the commercial strains have been distributed by live-stock and by moving surface water.

Hard seeds are a feature of the species, particularly where ripening is associated with low atmospheric humidities. Although low-growing types are now fairly widespread, increases in productivity appear to be obtainable by the use of more vigorous strains such as the Palestine type.

The introduction and commercialisation of this clover provides further demonstration that overseas sources of superior strains of herbage plants are not yet fully exploited.

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The Australian Institute of Agricultural Science

MEETING OF COUNCIL.

At the meeting of Council held on 14th July at the School of Agriculture, University of Melbourne, it was decided on a majority vote to accept the nominations forwarded by the South Australian Branch for membership of the Qualifications Committee, and to appoint thereto Professor J. A. Prescott, Dr. A. R. Callaghan and Mr. R. Hill. The following were admitted to corporate membership: E. E. Ryan (W.A.), L. Judd (N.S.W.), E. G. Hallsworth (N.S.W.), J. C. Bell (Vic.), A. G. Goudie (Vic.), Mrs. J. M. Haughton (Vic.), L. R. Hoult (Vic.), A. J. McIntyre (Vic.) and C. G. Welb (Vic.). The following were admitted to student membership: Miss M. Lane (N.S.W.), L. E. Rippon (N.S.W.) and K. D. McLachlan (N.S.W.). In regard to the resolution of the A.C.T. Branch concerning the establishment of an organisation for research in agricultural economics, Council decided to take no further action in this matter for the time being, but directed that the views of delegates should be supplied to those members of the Institute who would be attending the conference on agricultural economics to be convened by the Australian National Research Council at Melbourne University on 24th-25th July. The report of the Business Manager of the Journal (Dr. N. S. Noble) for Volume 6 was adopted and appreciation expressed of the excellent services rendered. Council strongly opposed the motion of the N.S.W. Branch that the Institute recommend to the Federal Government the desirability of employing agrostologists to aid in the selection, preparation and maintenance of aerodrome sites and surfaces. In reference to the question of "letters to the editor", raised by the Editor (Dr. H. J. Hynes), Council reaffirmed its earlier ruling, viz. that all letters must be published over the name of the author and that if they involved questions of ethics they should be referred to the Council prior to publication. It was also directed that a disclaimer by the Institute for responsibility of accuracy of statements or opinions in letters or articles be published in each issue of the Journal. Council decided that the Plant Quarantine Report of the Institute should be published in the Journal. The financial statement showed a balance at bank of £182 9s. The Hon. Treasurer presented the audited accounts for 1940, published in this issue.

MEETINGS OF BRANCHES.

Australian Capital Territory Branch.

At the sixth annual general meeting held in March, Dr. J. G. Davies was elected president for 1941. The meeting, held on 2nd April, was addressed by Dr. J. R. A. McMillan, the subject being "Home Production of Agricultural Seed in Australia". On 30th April, Dr. H. C. Coombs addressed the Branch on "Research in Agricultural Economics". Questions related to the wartime production of flax in Australia were dealt with by Mr. W. J. B. McDonald at a meeting in June. The July meeting was addressed by Mr. A. Howard of the C.S.I.R. Research Station at Griffith, who spoke on the soil as a medium for plant growth, with special reference to the work of the Station.

New South Wales Branch.

At the meeting held on the 11th July, under the chairmanship of Mr. G. de V. Davis, a symposium was held on the subject of "Fertilisers—Recent Concepts and their Relation to Agricultural Practice". The principal speakers and the subjects of their contributions were Professor E. Ashby (Plant Nutrition), Dr. E. G. Hallsworth (Plant Nutrients in the Soil), Dr. E. T. Edwards (Fertiliser Application and some New Characters of Fertilisers), and Mr. F. C. McCleery (Design and Conduct of Fertiliser Experiments). Many speakers participated in the after-discussion.

It was indicated that the chief physiological problems of plant nutrition are connected with (*a*) the entry of salts into the root; (*b*) the function of the salts in plant metabolism; and (*c*) the effect of one salt upon the uptake and utilisation of another. In regard to plant nutrients in the soil, the principal points discussed were their movements, as influenced by type of fertiliser and soil as well as the base and moisture status, and their fixation and exchange, which was exemplified by specific instances. The effectiveness of fertilisers was discussed with reference (*a*) to their time of application being correlated with the seasonal absorption of nutrients by the plant, and (*b*) to their placement. An account was given of the recent development and the practical advantages of a larger particle size of fertilisers. In the design and conduct of fertiliser experiments, it was pointed out that the precise comparison desired had to be kept prominently in mind, and the objectives of securing accurate yields and a measure of their reliability had to be provided for in the technique. The outstanding value of factorial designs for fertiliser trials and the need and technique of measuring residual effects were stressed.

Victorian Branch.

Institute members attended the following meetings of the Melbourne University Agricultural Society :

On 23rd May, Mr. C. S. Elliot, Officer in Charge of the Timber Seasoning Section of the Forest Products Laboratory, C.S.I.R., spoke on " Wood and the Farmer ". Mr. Elliot described the timber needs of the new settler and pointed out that because he had to select and prepare timber himself, he must be fully informed of the various types and the best uses to which they could be put. For those who lacked adequate supplies of durable timbers, say for fence posts, a simple, open tank treatment was available. White ant attack could be overcome by capping timbers. Spray treatment had overcome the unsuitability of certain timbers for export butter boxes.

Mr. W. R. Jewell, Agricultural Chemist of the Department of Agriculture and a member of the Power Alcohol Committee, addressed members on 26th June on " Power Alcohol from Farm Products ". Mr. Jewell traced the history of power alcohol production in Australia and showed that it was an economic proposition only if considered from the defence angle or for the stabilisation of an agricultural industry. Apart from molasses, sugar and wheat were the only products which would yield alcohol at a wholesale price of 2/- a gallon, and then only within certain limits. Any suggestion that more of a particular product, of which there was already a surplus, should be grown specifically for the manufacture of power alcohol was economically unsound. The speaker outlined the recommendations of the committee and gave figures to illustrate their effect on Australian economy.

On 24th July, Mr. G. B. Tindale, Cool Storage Research Officer of the Department of Agriculture, discussed " Recent Advances in the Technique of Fruit Preservation ". He put forward the interesting suggestion that those varieties of apples, pears and plums which developed disorders in cool store were the ones that had a ripening temperature of the order of 30° F. above their storage temperature. These facts were supported by experimental data.

Queensland Branch.

The meeting held at the University on 4th July, 1941, was devoted to notes and exhibits. Mr. A. F. Bell exhibited an instrument developed by the Bureau of Sugar Experiment Stations for measuring rind hardness of sugar cane varieties. Hardness of rind is important in connection with beetle borer. The instrument actually measures the relative fibre content of canes. The speaker also presented a note on delaying flowering of canes by defoliation in order to secure crossings otherwise unobtainable.

Mr. R. F. Langdon exhibited four diseases of forest blue grass (*Bothriochloa intermedia*) and drew attention to the danger of advocating culture of this grass in place of Rhodes grass.

Mr. C. R. von Stieglitz discussed the soil plaque method of ascertaining nutrient deficiencies in soils and exhibited plaques of the fungus Cunninghamella used for determining the phosphate status of soils.

Mr. W. A. T. Summerville submitted a note on a randomised block fertiliser trial with beans on steep coastal country, in which residual effect of sulphate of ammonia application was evident for months afterwards. No lateral movement of the fertiliser had occurred.

Mr. J. H. Smith discussed entomological aspects of the sorghum midge, and Mr. W. G. Wells followed with an explanation of various agronomic features of the sorghum plant which prohibited the adoption of the obvious entomological remedy of early planting of grain sorghums.

Mr. S. T. Blake showed various species of Cyperus closely allied to nut grass and often mistaken for that pest.

South Australian Branch.

A well attended meeting, with a large number of visitors, was held on 26th June. A film evening had been arranged to arouse interest and discussion on the place and comparative value of silent and sound film and the still projection. Films of agricultural subjects collected from various sources were screened. The subject is a live one and the cause of considerable experimentation in this and other States. There was some difference of opinion as to the extent films could be used in educational work, and the merits of silent and sound films. The necessity for good films to be effective and the difficulties of amateur production were emphasised.

Western Australian Branch.

Proceedings of the June meeting are summarised under " Agricultural Economics " (second portion) in the Current Notes and News section.

The meeting held on 1st August was devoted to a discussion of tobacco production in Australia with particular reference to Western Australia. Mr. W. P. Cass Smith opened the discussion with a review of the various changes in customs and excise duties on tobacco and their effects on tobacco production in Australia. The duty of 5s. 2d. per lb. on imported tobacco imposed by the Scullin government in 1932 brought about a very big increase in Australian acreage. The

importance of tobacco as a source of revenue to the government is, however, an important factor in determining the attitude of governments towards Australian tobacco production. Federal revenue from tobacco was £8,000,000 in 1938-39 compared with £12,000,000 from income tax. Production in W.A. has been confined almost entirely to the Manjimup district, where steady progress has brought the area cropped to about 1,200 acres, and W.A. is now third among the States for amount of production, and second only to Queensland in the quality of the leaf.

Mr. G. H. Burvill dealt with the importance attached to soil and climate in determining the quality of bright flue-cured tobacco, and suggested that undue emphasis may have been placed on the necessity for light sandy soils. Low inherent fertility, which allows greater control of plant nutrient status through fertilisation, may be the really important factor. The black turf soil of Transvaal, a heavy clay, but not inherently of high fertility, was instanced to support this view. Some W.A. tobacco soils are more clayey than classical American tobacco soils, but are of low natural fertility.

Mr. J. M. Allen then followed with a review of the past season's results at Manjimup and the introduction of an appraisement scheme to replace the auction system during the war. The gradual decline in British and Australian growers and the increase in southern Europeans was especially mentioned. Over 90 per cent. of the Manjimup growers are now southern Europeans. The high labour requirement of the tobacco crop and present labour difficulties were stressed. The changes in smoking habits since the Great War were reflected in Australia by the gradual development of areas where flue cured bright tobacco for cigarettes could be produced instead of the darker pipe tobaccos. North Queensland and Western Australia have proved especially suitable.

Tasmanian Branch.

The committee of the Tasmanian Branch decided to continue in 1941 the practice of holding periodic open general meetings, which were to be of a semi-social nature, taking the form of an address followed by general discussion, and concluding with supper. At the first meeting, held in Launceston on 20th March, the President of the Branch, Mr. J. T. Armstrong, spoke on "Dairy Herd Improvement", and stated that the economic development of agriculture along the north-west and parts of the north-east depended on the economic expansion of dairying, which in turn was dependent upon the evolution or selection of types of dairy cattle which had the ability to produce large quantities of milk with a reasonably high butter fat content, which were capable of producing a sound and healthy calf each year, and which were long lived and free from disease. Herd improvement could not be effected by selection from breed type alone. It was dependent upon breeding from proved producers only, and the culling of all cattle which had not given a payable yield.

At the June meeting, Dr. J. W. Evans addressed members and visitors on the activities of the entomological division of the Department of Agriculture, and stated that the work comprised research, advisory work, and certain aspects of plant quarantine. The principal research projects undertaken during the past six years have been concerned with the light brown apple moth (*Tortrix postvittana*) and certain pasture pests known as underground grass grubs (*Oncopera* spp.). In addition several minor research projects have been completed. In the field of biological control, an egg parasite of the canary fly (*Typhlocyba froggatti*) had been introduced and was being distributed to all orchard centres. A weevil (*Apion ulicis*) that destroys gorse-seed had been introduced and established, but not yet distributed. In addition, parasites of the oak pests have been distributed all over the State. In the field of plant quarantine, endeavours have been made to prevent the introduction of certain insect pests from the mainland of Australia. These have been successful in some instances (e.g. the oriental peach moth); in others they have failed (e.g. the cabbage butterfly). The advisory service is called upon to cope with a wide range of enquiries, by no means all of an agricultural nature.

Current Notes and News

Agricultural Economics.

It is proposed to establish an agricultural economics research bureau as a division of the Department of Agriculture at Sydney, New South Wales. Mr. T. G. Crawford has been appointed as Advisory Economist to the Department, and will supervise the research activities of four officers who are to be appointed. These positions represent the nucleus of a unit which may ultimately comprise 14 or 16 officers.

The work of the bureau, which will be conducted in closest cooperation with members of existing Divisions, will include cost of production surveys, economic aspects of such problems as fodder conservation, water conservation and soil erosion control, land settlement problems,

analysis of debt structure, marginal area problems, land use surveys, market outlets for agricultural commodities, and special studies of wartime problems, organisation of industries, price-fixing and disposal of surplus products.

At a well attended meeting of the W.A. Branch of the Institute held in June, at which several members of the W.A. Branch of the Economic Society of Australia were present, a discussion took place on " Rural Economics ". Professor G. A. Currie, in opening the discussion, said that there was a world trend for a smaller proportion of people to be engaged in agriculture because of mechanisation, and this trend would almost certainly continue. Farmers' products were forced down in price in relation to other goods. Farming was a depressed industry. Equality of opportunity was a cardinal principle in democratic countries, but farmers did not enjoy that equality with urban dwellers. They were an under-privileged class. There was no great hope for the future of wheat so far as big prices were concerned. Could men be transferred from wheat farming to other types of farming or other industries, or must the State lose population to the eastern States ? If there was a greater demand for meat, dairy products, eggs and even honey it was possible that wheat farmers would be transferred to the south-west. He did not feel as pessimistic about wool as about wheat. Although wool prices would probably be pegged by the use of substitutes, no substitute had all the properties of wool. In an under-privileged community, there was a danger of " poor white trash " developing as in America. If we left people on farms producing wheat at a loss, we should at least extend social services to them and give them equality of opportunity with city people.

Mr. Baron Hay said that, while he agreed with the necessity for precise information covering the matter embraced in the term " agricultural economics ", there was some doubt in his mind whether the problems usually placed at the head of the list as needing urgent attention were the ones upon the solution of which the welfare of the farmer was most dependent. He did not think that the economist could assist the farmer in the same way as he had assisted the industrialist, as in the latter case if there was not a profitable market the industry did not come into existence. Until such time as a method was found whereby marketing of agricultural produce could be placed on a basis somewhat similar to that of the marketing of manufactured goods he felt that investigations into farm economics would not necessarily benefit the farmer. However, he felt there was an urgent need for a study of wider problems, such as effects of national income in importing countries on places like Australia, methods of financing farm credit, farmers' and farm workers' living standards, etc. The fact that Australia had spent probably less than any other country which depended so largely on the export of primary products, did not mean that any disability had been experienced. Agriculture had been developed in what was previously virgin country and it was more than probable that if economic surveys had been made before settlement, based upon the results and information available in older settled countries, development might have been retarded if the political sphere had strictly followed the result of such surveys. He thought that agricultural economics research might now be worth while, but he felt that as at present the farmer had no control over prices, the problems which should be attacked first should be the broader ones involving the welfare of the farmer and conditions affecting marketing rather than the minor problems of farm costing and management which varied so greatly from farm to farm, from district to district and from season to season and were affected by international political policies.

Rothamsted Field Experiments on the Growth of Wheat.

This is the title to Technical Communication No. 40 of the Imperial Bureau of Soil Science, prepared by Sir E. J. Russell and D. J. Watson.

The Rothamsted experiments on wheat for nearly a century have provided fundamental information for the agricultural scientist regarding the cultivation and manuring of wheat. The experiments on Broadbalk were the first to establish the importance of nitrogenous fertilisers, and to refute the views of Liebig that all crops could receive their nitrogen from atmospheric sources. The results of these long continued experiments were summarised in 1893 by Lawes and Gilbert, and again in 1905 by A. D. Hall. Since then the mass of data has been worked over by the statistician, starting with the classical paper by R. A. Fisher in 1921 on crop variation. The technical communication under review brings together in a convenient form all the information that has so far been obtained in the Rothamsted experiments on wheat, both when grown continuously and in rotation, and the results are compared with those obtained at Woburn and elsewhere in Britain. The results obtained more recently by the crop physiologists in the course of measurements on growth and development in the field are also dealt with. The publication will be a valuable addition to the library of the agronomist and agricultural scientist generally, as a source of reference to the Rothamsted experiments themselves and as a source of inspiration for the method of approach to experimental work with crops generally. For a technical communication it has the rare quality that it will not date and that it will continue to be the main source of information on Rothamsted work on wheat for many years to come.

J.A.P.

" Soil Conservation ", by H. H. Bennett.

Dr. H. H. Bennett, Chief of the Soil Conservation Service of U.S.A., is the author of a recent book entitled " Soil Conservation ". Dr. Bennett is regarded as one of the leading authorities on this subject, and his book contains a wealth of information based on very close association with the complexities of the problems involved. Referring to this new volume recently, Mr. E. S. Clayton, Director of the N.S.W. Soil Conservation Service, stated : " It is the most useful textbook to have reached the Australian and New Zealand conservationist and agriculturist for many years. It deals authoritatively with the new and highly important science and practice of soil conservation. It is at once a textbook for the student and an amazingly useful and clearly set out guide for the practical landowner who wishes to check erosion."

Doctorates Conferred.

Mr. I. A. Watson received the Ph.D. degree from the University of Minnesota in March, 1941 his thesis dealing with the effects of association on the development of physiological races of wheat stem rust. After graduating in agricultural science with first class honours at Sydney University in 1938, Dr. Watson was awarded a Commonwealth Research Scholarship to carry on investigations into cereal diseases at Sydney University. In May, 1938, he was appointed Assistant Lecturer in the Faculty of Agriculture and in February, 1939, gained the Thomas Lawrence Pawlett Scholarship and proceeded to U.S.A. While at Minnesota he was elected a Fellow of the American Association for the Advancement of Science. Upon his return to Sydney in February, 1941, he resumed his position in the Faculty of Agriculture.

In June last, Mr. S. L. McIndoe was admitted to the Ph.D. degree at the University of Minnesota. His thesis was entitled " The nature and inheritance of resistance to stem rust of wheat, *Puccinia graminis tritici*, possessed by several resistant varieties ". Dr. McIndoe graduated B.Sc.Agr. with honours at Sydney University in 1928 and was then appointed to the N.S.W. Department of Agriculture to take up plant breeding work at the New England Experiment Farm, Glen Innes. As Farrer Scholar, he travelled for several months in 1931 in U.S.A., Canada and Great Britain, investigating methods of plant breeding. On his return to Glen Innes he resumed breeding work with several crops, disease resistance and quality in cereals being his major interest. In 1939 he was awarded a Commonwealth Fund Fellowship, under which he studied at Minnesota and travelled extensively in U.S.A. He returned to Sydney last month and is now located at the head office of the Department, assisting with cereal investigations.

Advice has just been received in Sydney that Mr. T. J. Marshall, an officer of the Soils Division, C.S.I.R., stationed at the Waite Institute, has received his Ph.D. degree from the University of California.

Book Review

THE BIOCHEMISTRY OF SYMBIOTIC NITROGEN FIXATION, by Perry W. Wilson.

(*Pp. xiv+302 with 34 plates, 27 diagrams and 22 tables. University of Wisconsin Press.* 1940. *Price* 3.50 *dollars.*)

This is an extremely valuable book, written by an eminent authority on the biochemistry of symbiotic nitrogen fixation.

The first chapter deals in a masterly way with the importance of maintaining a nitrogen cycle in agriculture. The author stresses the seriousness of losing soil nitrogen by exploitive farming and shows that these losses cannot be restored by the use of costly artificial fertilisers, but may be prevented by the scientific control of symbiotic and non-symbiotic nitrogen fixing bacteria.

The chapter entitled " Leguminous Plants in Agricultural History " introduces the reader to many historical papers, now difficult to obtain, written during the last century at a time when nitrogen fixation by legumes was first being demonstrated. The biochemistry of the bacteria growing on artificial media is dealt with rather fully, including the recent work on their growth factor requirements and respiratory enzymes.

By far the greater part of the book is devoted to the more modern research which treats host plant and bacteria as a whole rather than as separate entities. The symbiosis which results in the fixation of nitrogen is complicated by numerous factors and the mere presence of root nodules is no criterion that nitrogen fixation is occurring. The efficiency of nitrogen fixation may be influenced by effective or ineffective strains of bacteria which exist in the same cross-inoculation group, and in addition by host plant specificity. Such factors as the carbohydrate-nitrogen relationship existing in the plant, the intensity and duration of sunlight, the reaction of the soil, the availability of certain minor elements, and the presence of bacteriophage influence fixation.

Wilson deals fully with the controversy existing between Virtanen in Finland and the American workers over the question of legumes excreting nitrogenous substances. He concludes that the peculiar climatic conditions obtaining in Finland promoted the excretion of aspartic acid and beta-alanine, whereas no such substances were detected when similar experiments were conducted at Wisconsin. Theories concerning the mechanism of the process of symbiotic nitrogen fixation are discussed and the three hypotheses which postulate ammonia, hydroxylamine or organic nitrogen as intermediate substances are examined. The obscurity and complexity of these reactions are well illustrated by the almost complete absence of chemical symbols in what is actually a biochemistry textbook.

In the concluding chapters the author deals with some practical aspects of the problem. The first question is whether legumes benefit non-legume crops growing in association. Field evidence showing that young legumes excrete nitrogenous compounds from their roots is rather scanty, but there are numerous experiments showing that non-legumes can benefit from associated older legumes after the root nodules decay and nitrogen is liberated. The second question deals with the effect of nitrogenous fertilisers on legumes. On the whole, the presence of available soil nitrogen reduces the amount fixed by the root nodules, but sometimes a very small dressing of nitrogenous fertilisers at the time of sowing is advantageous as it prevents nitrogen starvation in the short period before root nodules form. Another practical consideration is that of artificially inoculating legumes with effective strains of bacteria. In view of the fact of host specificity it might be advisable to use mixed cultures containing several strains of Rhizobia. Next the author touches on the subject of carbon dioxide fertilisation by the decomposition in the soil of green manures. Finally the benefit of applications of lime, phosphates and borax on legumes growing in deficient soils is mentioned.

The bibliography is very full and the author has made it particularly useful by putting in brackets the page in his textbook where the various research papers are cited and discussed.

R. J. Swaby.

Obituary

RICHARD THOMAS BAKER.

The death occurred recently of Mr. R. T. Baker, who, for many years, occupied the position of Curator of the Sydney Technological Museum. Although a man of wide interests, his main activities were directed towards botanical research, and he made many contributions to the knowledge of the Australian flora. He was keenly interested in the Eucalypts, and, in collaboration with the late H. G. Smith, published the authoritative book, " The Eucalypts and Their Essential Oils ". Always interested in the practical value of Australian trees, he was one of the first to make detailed investigations into the native timbers, his books such as " The Hardwoods of Australia " and " Cabinet Timbers of Australia " being generally accepted as classical references. He made many other contributions to Australian botanical science, his work being always characterised by originality and enthusiasm, combined with great ability.

For many years he held the position of Lecturer in Forestry at the Sydney University, and many members of the Sydney Branch of the Institute have very happy recollections of their association with him as students. We, who knew him and his work, pay tribute to his fresh and vigorous personality and to the enduring value of his researches.

R.H.A.

CLIFTON EDWARD AHRENS.

A promising career has been cut short by the sudden death at the early age of thirty-two years of Clifton Edward Ahrens, B.Sc.Agr., Superintendent of Lord Howe Island. He entered the Faculty of Agriculture, Sydney University, with a Public Exhibition and an Agricultural Department Cadetship from Lismore High School in 1927, and graduated in 1932. He took a prominent part in the general life of the University, and in addition to being Senior Student at Wesley College and President of the Christian Union, he sat on the Union Board of Directors and was a member of the Students' Representative Council. He toured New Zealand with the Australian Universities football team in 1929, played inter-faculty cricket and tennis and was awarded the Wright Cup for the display of Faculty spirit in 1931. He was particularly keen on the Boy Scout Movement and organised very successfully the scouting work of the University Settlement.

After five years in agrostological work with the State Department, he left for Fiji early in 1937 to become Principal of the Navuso Agricultural College but, after a few strenuous years, had to abandon the work owing to ill-health. Some months later, he was appointed Superintendent of Lord Howe Is., but the old trouble returned and he was ordered back to Sydney, where he suddenly collapsed on 24th June. Warmest sympathy is extended to his widow and two young children.

Personal Notes

Mr. L. F. Mandelson, of Queensland, has been seconded to the Australian Tobacco Board to act as arbiter to the Tobacco Appraisal Committee.

Lt.-Col. J. K. Murray is Camp Commandant at Redbank Military Camp, Queensland.

Mr. J. L. Gillespie has resigned his position as Secretary of the Melbourne University Appointments Board to take up an administrative position with a Sydney engineering firm.

Mr. A. C. Smith has resigned as Cheese Expert of the Department of Agriculture, Victoria. He is now with Kondoparinga Dairyman Ltd., Meadows, South Australia.

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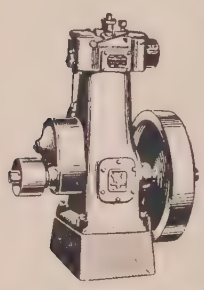

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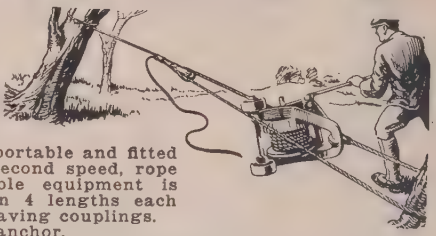

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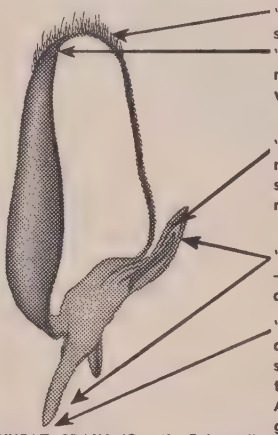

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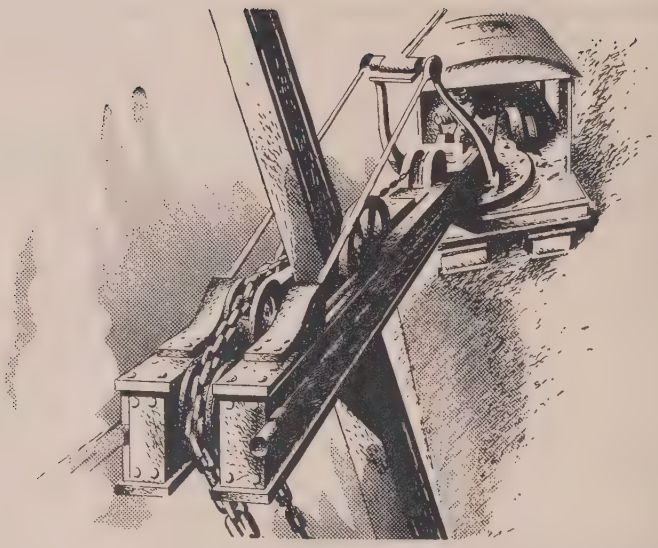

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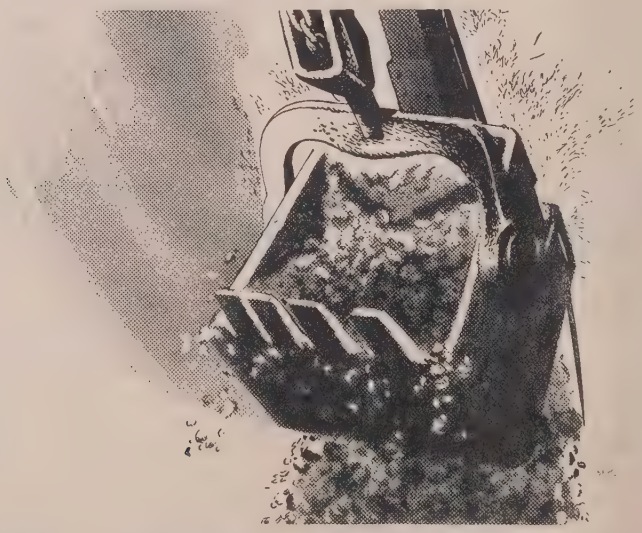

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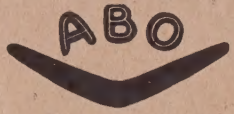

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